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THE SUTURE OF BLOOD VESSELS. IMPLANTATION AND TRANSPLANTATION OF VESSELS AND ORGANS. AN HISTORICAL AND EXPERIMENTAL STUDY.[1]

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It is only in comparatively recent years that conservative methods have been employed in dealing with the larger blood vessels in the human body. This advance is in a large measure due to the results obtained by the application of modern surgical technic to animal experimentation.

The ligature, which during the middle ages waged a constant warfare with cauterization, compression and other methods of hæmostasis, was toward the end of the eighteenth century recognized as the best method for controlling hæmorrhage from large and small blood vessels. Inasmuch as ligation of the large vessels not infrequently gave rise to gangrene and sometimes caused loss of life, this method was not an ideal one. Some years elapsed, however, before further progress was made; then surgeons began to apply the lateral ligature in partial wounds of veins where the continuity of the vessel was not interrupted. This method was first used successfully about the beginning of the nineteenth century (1), but, as was the case in other branches of surgery, first came into general use after the introduction of antiseptics. The lateral ligature has the disadvantage that it can be used in only a limited number of cases, for if the wound in the vessel is large the ligature will produce considerable narrowing of its lumen and there is danger of the ligature slipping. To meet these difficulties various clamps were devised for approximating the edges of venous wounds during the process of healing, but the great objection to this method, although it was a step in the right direction, was that it prevented primary healing of the cutaneous wound.

The Lateral Suture of Veins and Arteries.

The problem was solved by the introduction of the venous suture, which was carried out for the first time successfully by Schede (2) in 1882. This method was later employed in numerous cases and has now come into such general use that almost every surgeon of experience has had occasion to use it.

The beginning of a conservative treatment of arterial wounds antedates by more than a century the first experiments with the lateral suture of veins. In 1759 Hallowell, an English surgeon, at the suggestion of Lambert (3), who had observed the spontaneous healing of vessel wounds after venesection, sutured an artery in man for the first time. A small wound in the brachial artery was closed by placing a pin through the lips of the wound and passing a thread around it. The patient recovered and the radial pulse remained nearly as strong as that in the other arm.

In 1772 the question of arterial suture was tested experimentally by Asman (4), who closed wounds in the femoral arteries of four dogs by the same method which Hallowell had employed in man. None of these experiments were successful, and Asman therefore declared the method insecure and

[1] From the Hunterian Laboratory of Experimental Medicine, The Johns Hopkins University.

dangerous. It was not until 1881, after antisepsis had gained a firm foothold, that arterial suture was again tried in animals, but without the desired result. In 19 cases Gluck (5) sutured longitudinal wounds in the common iliac arteries of large dogs and in the aorta of rabbits, but there was always hæmorrhage from the stitch holes and in tying the sutures tears were often made in the vessel wall. To overcome these difficulties he later constructed small ivory clamps, with which the wound in the artery was closed and which were allowed to remain in situ. In this manner he succeeded in closing a partial wound of an artery with preservation of its lumen. Several years later v. Horoch (6) experimented with arterial suture, but, likewise, with little success.

To Jassinowsky (7), who published the results of his experiments in 1889 in his inaugural dissertation, belongs the credit of having proven conclusively that arterial wounds can be sutured with preservation of the lumen of the vessel. He avoided the femoral artery, which had been used by previous experimenters, and used the carotids of large dogs, horses, and calves, making longitudinal and transverse wounds in the vessels and then suturing them. The longitudinal wounds varied in length from 3 mm. to 2 cm. and the transverse wounds included $\frac{1}{3}$ to $\frac{1}{2}$ of the circumference of the vessel. Of 26 experiments, all were successful except four, and in none of the successful cases was there secondary hæmorrhage, thrombosis or aneurysm formation, although some of the specimens were examined as late as a hundred days after the operation.

Histological examination of the old scars showed the following condition: There was a small gap in the elastic membrane at the site of the suture, the ends of the membrane being usually slightly everted, leaving a small angle, filled with fibrous connective tissue, which toward the lumen was covered with endothelium. The media showed an increase in its cellular elements, and there was an irregular arrangement of the elastic lamellæ and muscle cells, the nuclei of the latter being quite large. The adventitia was greatly thickened consisting of a fibrous connective tissue poor in cells.

Jassinowsky attributed his good results to his technic and to the fact that he experimented upon vessels of large caliber. He used fine curved needles and fine silk, the interrupted sutures being placed about 1 mm. apart, including only the media and adventitia and avoiding the intima. As a result of his experiments he reached the following conclusions: (a) The arterial suture heals by first intention; (b) bleeding after operation can be surely and completely avoided; (c) secondary hæmorrhage and thrombosis are not to be feared; (d) suture should be done in all recent, clean longitudinal, oblique, and flap wounds of large vessels and in transverse wounds not exceeding one-half the circumference of the vessel; (e) the strictest asepsis is necessary; (f) the suture is easily done.

In 1890 Burci (8), by experiments on the femoral and carotid arteries of dogs and horses, confirmed the results obtained by Jassinowsky. Of six experiments four were said to have been successful. He used fine round needles and a continuous silk suture, only the adventitia and media being included in the suture.

In the summer of 1894 Heidenhain (9) made several experiments upon the carotid and femoral arteries of dogs, suturing partial wounds in these vessels with a continuous catgut suture, approximating intima to intima. None of these experiments were successful; hæmostasis was perfect but the lumen was occluded by the suture. He attributed his failure to the small caliber of the vessels and the coarseness of his suture.

Murphy (10) in 1897 published the results of numerous experiments with the partial suture of arteries along with other experiments with the resection of arteries.[2] He sutured 11 partial wounds in the abdominal aorta, carotid, femoral and iliac arteries of dogs and two wounds in the carotids of sheep. These were longitudinal and oblique wounds $\frac{1}{4}$ to $\frac{5}{8}$ inch in length and transverse wounds including $\frac{1}{3}$ of the circumference of the vessel. Of the 13 sutures 6 were entirely successful, the lumen of the vessels being preserved. In 10 cases a continuous suture of fine silk, including all the coats of the vessel, was used; in one, interrupted silk sutures were used, and in two, kangaroo tendon was the suture material. As the means of provisional hæmostasis Billroth clamps armed with rubber were usually used, sometimes a heavy silk thread twisted and held with the fingers.

As a result of his own and the experiments of others Murphy came to the following conclusions: (a) Besides the most careful asepis, a good technic is necessary for the success of vessel suture; (b) the vessel must be exposed very carefully and a good means of provisional hæmostasis applied; (c) the edges of the wounds must be accurately approximated and bleeding completely stopped; (d) as suture material he recommends silk which should include only the outer coats of the vessel; (e) he recommends the suture of the vessel sheaths and surrounding tissues as a support to the vessel suture.

In 1897 and 1898 Silberberg (11) experimented with the arterial suture in dogs. He applied 12 longitudinal and 6 transverse sutures, 10 in the femorals, 6 in the common carotids, and 2 in the abdominal aorta. Five of the longitudinal and 3 of the transverse sutures were quite successful. For a successful suture Silberberg emphasized the importance of an absolute asepsis. As suture materials he used the finest Hagedorn intestinal needles and the finest silk. With the exception of three cases in which he used interrupted sutures, he made use of the continuous suture, which can be applied more rapidly. He does not attach much importance to the question as to whether the suture should or should not penetrate the intima, but thinks that sutures exposed in the lumen may contribute to thrombus formation. He thought a method of provisional hæmostasis, which spares the vessel wall as much as possible, was very important and made use of heavy silk threads which were passed around the vessel and,

[2] Vid. infra.

after being twisted, were held thus by means of clamps. The slight bleeding from the stitch holes is easily stopped by a little compression. As an additional support he recommends the suture of the vessel sheath. Concerning the indications for vessel suture this author says: (a) The wound should be clean; (b) only large vessels, such as the aorta, the carotid, subclavian, axillary and femoral vessels, should be sutured; (c) longitudinal, oblique, and transverse wounds, which do not exceed one-third of the circumference of the vessel, are adapted to suture.

Napalkow (12) in 1900 reported the results of his experiments with the suture of wounds in the heart, arteries, and veins. Of 14 sutures in the abdominal aorta and carotids of dogs, in six there was bleeding at the site of the suture. Of 10 venous sutures only one bled. Napalkow used fine round needles and continuous sutures of fine silk, including all the coats of the vessel. As the means of temporary hæmostasis he employed a thread twisted about the vessel or clamps armed with rubber.

In 1899 Dörfler (13) published a very interesting and instructive paper, describing the results of his experiments with the suture of arteries. Altogether there were 20 experiments, 16 being simple sutures of longitudinal, oblique and transverse arterial wounds with 12 successful results and 4 being sutures of completely divided arteries, which will be described later.[2] As the result of his experiments, Dörfler came to the following conclusions: (a) Arterial suture is only indicated in clean wounds; (b) for temporary hæmostasis the best means are compression with the fingers, strips of gauze twisted together, or clamps armed with rubber; (c) fine needles and a continuous suture of fine silk including all the coats of the vessel should be used; (d) slight pressure upon the suture for a few minutes after its completion will readily stop bleeding; (e) the vessel sheath should also be sutured.

Jakobsthal (14), who examined Dörfler's specimens histologically, found that the process of healing of arterial wounds proceeds as follows: The incision becomes filled with blood and fibrin, there being only slight deposits within the lumen about the suture and upon the inner aspect of the vessel wound. These deposits are very early, even in the first few days, covered with endothelium. Soon there is an active formation of new connective tissue and blood vessels in the adventitia and to a lesser extent in the media. These make their way into the clot and in a certain measure organize it, thus forming an end-, mes-, and peri-arteritic growth rich in cells. Then there is a retrogressive process; the cells become fewer and less rich in protoplasm, while a fibrous substance appears between them. This substance in the media and adventitia is chiefly connective tissue with a few elastic elements, while in the intima there is an extraordinarily rich new formation of fine elastic lamellæ and fibers which may lead to the formation of a kind of secondary elastica, at least in the region of the scar.

Salvia (15) in 1902 experimented upon dogs, goats, and a donkey in order to study the process of healing arterial wounds. He partially divided the vessels and closed the wounds with interrupted sutures. He found that, with the exception of the elastic fibers, there is a complete restitution of the vessel wall.

In 1906 Dorrance (16) published a method of vessel suture, which he claimed to be original with him, but which is almost identical with that described by Clermont (17) in 1901. Dorrance used a continuous mattress suture of fine Pagenstecker's thread with the dropping-back one-half a suture length every third suture, continuing the same suture as a whip-stitch over the everted edges of the artery after completing the mattress suture. With this method he experimented with the closure of wounds in arteries and the union of completely divided arteries.

There were 14 operations in all, nine on horses and five on dogs, and of the 14 wounds 12 suppurated. There were three complete circular and 11 partial transverse, oblique and longitudinal wounds. Ten of the vessels were examined from 2 to 14 days, and the other four from 21 to 42 days after the operation. In seven no thrombus was visible, in five a small mural thrombus was present and in two complete thrombosis. These are remarkably good results considering the number of suppurations. I am inclined to think that, had the specimens been examined at longer intervals after operation, more complete thromboses would have been present, especially when we consider the number of cases in which mural thrombi occurred.

While animal experimentation has shown conclusively that arterial wounds can be sutured successfully, numerous instances of successful suture of accidental wounds of arteries in man have demonstrated the practical value of this procedure. Such cases have been reported by Heidenhain (18), Israel (19), Ssabanejew (20), Orlow (21), Lindner (22), Garré (23), Seggel (24), Veau (25), Heinlein (26), Baum (27), Torrence (28), and others. Up to July, 1902, Schmitz (29), was able to collect 21 cases of lateral sutures of arteries in man, the axillary artery having been sutured seven times, the femoral five times, the popliteal and brachial each three times, the common iliac, common carotid, and internal carotid each once. In 1903 Höpfner (30) collected 30 such cases.

Remarks.—The results of the foregoing experiments on animals and the clinical experience show that for a successful suture the following things are necessary: (a) A very perfect aseptic technic; (b) clean cut wound edges which can be approximated without too much tension; (c) very careful handling of the vessel without stripping its sheath too much.

While there is considerable difference of opinion as to whether silk or catgut is the best suture material, there is little doubt that the former is preferable. It can be obtained in finer sizes, handled much more easily, and sterilized more surely. The needles should be as fine as possible, but whether straight or curved depends upon the location of the vessel to be sutured.

The question as to whether the interrupted or continuous

[2] Vid. infra.

suture should be used, seems to be settled in favor of the latter, which is simpler and can be applied more rapidly. The question as to whether the suture should penetrate all the coats of the vessel or avoid the intima, seems of more importance. While Jassinowsky (7), Burci (8), and others recommend the avoidance of the intima, v. Haroch (6), Murphy (10), Dörfler (13), Dorrance (16), and others allow their sutures to penetrate the intima, in fact, in suturing veins it is almost impossible to avoid it. By including all the vessel coats the suture is not only simplified, but made more secure.

Various methods have been used for producing temporary hæmostasis, finger pressure, various clamps, strips of gauze, etc. Whatever method is employed, the main desideratum is to injure the vessel wall as little as possible. The pressure of the fingers is the gentlest method and should be used in man, where possible.

If there is leakage at the site of suture a slight compression will generally cause it to cease in a few minutes.

The Circular Suture of Arteries and Veins.

Inasmuch as the lateral suture was not successful in large transverse wounds of vessels and in cases where the edges of the wound were crushed or otherwise injured, attempts were made in such cases after resection of the vessels, and in complete transverse wounds of vessels, to unite the ends of the vessel by the simple circular suture, by protheses of various kinds or by invaginating one end into the other.

The circular suture of arteries.—The first experiments of this nature were those of Robert Abbe (31) of New York, who published his results in 1894. He divided the femoral artery of a dog and united it again by tying the ends together over a small hourglass-shaped tube of thin glass. The immediate result of the operation was very favorable, for the circulation of the leg was reestablished as soon as the clamps were removed and the dog recovered promptly. After some time the artery was removed and examined. The tube was found lying free in the lumen of the vessel which had become occluded a short distance below it. Abbe united the divided aorta of a cat in a similar manner and afterwards exhibited the animal, thinking that its survival demonstrated the patency of the aorta. This vessel, however, might have become gradually occluded without inconvenience to the animal.

In 1896 Briau and Jaboulay (32) made ten experiments with the circular suture of carotid arteries in dogs, the ends of the vessels being united with U-shaped sutures, which everted the edges and approximated intima to intima. None of the experiments were successful, all of the vessels becoming thrombosed. They later tried the method on a larger vessel, namely the carotid of a donkey, with perfect success. This method was tried in 1900 by Salomoni (33), who claimed the honor of discovering it.

Murphy (10) in 1897 published a very interesting and important article in which he detailed his numerous experiments with the suture of arteries and described a new method for the union of completely divided vessels. This method, which is said to give a more solid union than the simple suture, consists in invaginating one end of the vessel a short distance into the other and is done in the following way: After applying Billroth clamps armed with rubber, the artery is divided and the proximal end is invaginated into the distal by means of three or four double-needled silk sutures which include only the adventitia and media of the proximal end, but are passed through the entire thickness of the distal end. When these sutures are drawn up and tied the ends are easily invaginated and fastened in this position. After the invagination is completed, the free edge of the distal end is sutured to the proximal by several interrupted sutures which include only the adventitia and media of the proximal end, but the entire thickness of the distal. The invagination is sometimes facilitated by splitting the distal stump longitudinally for a short distance.

This method was tried on the carotids of dogs three times, on the carotids of calves four times and on the carotids of sheep four times, once on the femoral artery and abdominal aorta of dogs. Only three of these cases were successful, thrombosis occurring in the others. The unfavorable results were thought to be due in a large measure to the small caliber of the vessels which were used.

Murphy also made a few experiments with the simple suture of arteries, the carotids of sheep being sutured twice, the carotids of dogs and calves once each and the abdominal aorta of a dog once. The continuous suture was used four times and the interrupted suture once. Only one of the five experiments was successful.

The invagination method was tried by Dörfler (13) four times, twice in the carotids and twice in the femorals of dogs. In three cases thrombosis occurred; in the other case the lumen was unobstructed when the animal died of a venous hæmorrhage only three days after the operation.

In discussing Murphy's paper at the International Medical Congress in Moscow in 1897 Nitze (34) demonstrated some small ivory protheses, resembling those later described by Payr. They consist of small ivory cylinders over which the ends of the vessel are slipped in such a way as to approximate intima to intima. A simple ligature holds them in this position.

In 1898 Gluck (35), who had done pioneer work with the lateral suture of arteries, described a new method of circular suture. After exposing the artery and applying clamps armed with rubber, a small section of the artery was excised and slipped over one of the ends in the manner of a cuff; the ends of the vessel were sutured together with interrupted sutures which included only the adventitia and media, and then the resected portion was drawn over the line of suture and fastened thus with a few stitches. Instead of using a section of the artery to be sutured, rings of rubber and decalcified bone or a section of vessel from the same or another animal can be used.

Payr (36), fearing that a simple circular suture could not withstand the pressure within large arteries devised a method,

which he published in 1900, of uniting divided vessels by invaginating the ends over extra-vasal protheses of magnesium, which is absorbable in the body. If the vessel is an artery, the central end is invaginated into the peripheral, if a vein, the peripheral end is invaginated into the central. The protheses consist of hollow cylinders of magnesium, which have very thin walls and vary from .3 to 1 cm. in length. On the outer surface of the cylinder, near one end, there is a small groove, one-third to two-thirds of a millimeter deep, in which the ligature is placed. The method, as applied to arteries, is carried out as follows: After provisional closure and division of the artery, the central end is drawn through the cylinder, which just fits over the vessel, by means of three sutures placed in the end of the vessel, which, after being drawn through the cylinder, is everted over it and fastened thus with a ligature of fine silk. The peripheral end is then drawn over the everted cuff and also fastened with a ligature, broad surfaces of endothelium being thus approximated. Payr thinks the fact that the prothesis is absorbable is of great importance. This property of the prothesis is probably of very little importance, for it requires from two to four weeks, or even longer, to be completely absorbed.

Payr, who tried the method on the carotids of dogs and pigs, says it can be done very easily and quickly and claims to have obtained very good results with it; however he does not state how many experiments he has made and makes no reference to any journal of experiments. The article is illustrated with schematic drawings, all of his preparations having been destroyed in a fire.

In an article published in 1904 Payr (37), on the strength of the experiments of others with it, notably those of Höpfner (38), champions his method and says the unsuccessful experiments of Salinari and Virdia (39), Jensen (40), and Reinsholm (41) were due to the fact that they did not proceed according to his directions.

In 1901 Bouglé (42) performed a few experiments with circular suture of the carotids of dogs. He first used the method of Murphy, invaginating the ends by means of U-shaped sutures. The vessels, however, were so small that obliteration of the lumen always occurred. He then tried a new method, invaginating the ends only a few mm. and fastening them thus by interrupted sutures, which included only the media and adventitia. He mentions one case, in which both carotids were sutured, one by this method, the other by simple end to end union with interrupted sutures which did not include the intima. When examined 15 days after operation both vessels were patent, the intima was smooth and no clots were present.

In 1902 articles upon the circular suture of arteries by Salvia (43), Salinari and Virdia (39), Carrel (44), Thomaselli (45), and others appeared.

Salvia (43) made numerous experiments upon the femorals of dogs and the carotids of donkeys and sheep with special reference to the process of healing in wounds of arteries. He employed the end to end suture with fine silk, after resecting considerable lengths of the vessels. In none of the cases did the lumen remain patent. He examined the specimens histologically and found that, with the exception of the elastic fibers, there was a complete restitution of the vessel wall.

The object of the experiments of Salinari and Virdia (39) was: (a) To test the methods most often tried in animals and man and from the results to determine which offers the best chance of restoring the function of the vessel; (b) to investigate the healing process microscopically and see whether the arterial walls will be sufficiently strong at the sutured point. The experiments, about 30 in number, were done on large dogs, the carotid and femoral arteries being generally used, the abdominal aorta being used twice. With the exception of a few partial transverse and longitudinal sutures, the sutures were done on completely divided arteries. For provisional hæmostasis various clamps were used, but, finding these unsatisfactory, they constructed a special clamp with parallel blades, regulated by a thumb screw, which proved very satisfactory.

Of 16 sutures done according to Murphy's method, six became infected and the results were negative, six healed with mural or canalized thrombi; in two the lumen remained pervious, though considerably narrowed, and in two others the site of suture presented an almost normal appearance. The protheses of Payr were tried three times, two of the animals died of infection, the other of secondary hæmorrhage.

The authors conclude that suture is preferable to ligation in wounds of large size and that in cases of complete transverse wounds invagination is the best method, although their results would hardly justify these conclusions. In cases of *restitutio ad integrum* the vessel wall is richer in muscle cells and elastic fibers than under normal conditions.

Thomaselli (45) emphasized the importance of approximating intima to intima. In his experiments, which were done on the abdominal aorta, carotid and femoral arteries of 11 dogs and the femoral artery of one goat, the endothelial surfaces were held approximated by fine clamps, which were removed in turn as the suture proceeded. Interrupted sutures, passing through all the coats of the vessel were used and the suture materials were fine curved needles and silk thread. In seven cases there were positive results with or without narrowing of the lumen, in three the results were negative and in two others it was necessary to ligate on account of sclerosis of the vessel wall.

In an article published a year later Thomaselli (46) says, that the best method of vessel suture is that previously recommended by Salomoni (33), which consists in approximating intima to intima by means of U-shaped sutures transfixing the entire wall of the vessel. He studied the process of healing in transverse wounds to determine whether there is a real *restitutio ad integrum* as Burci had already observed in the case of longitudinal wounds. Histological examination showed the following: (a) The muscular layer is completely regenerated; (b) the elastic fibers of this layer are regenerated and are more numerous at the edges of the scar and near the lumen where they do not form a real inner elastic

membrane, but they replace this membrane and prevent the formation of an aneurysm; (c) neither the inner elastic membrane nor the elastic fibers of the adventita are reformed, the latter being composed of fibrous connective tissue; (d) close up to the suture one can demonstrate the complete restoration of the three layers with hypertrophy of the muscle cells and elastic fibers.

In 1902 Carrel (44) published a method of circular suture, which, while differing very little from certain methods previously employed, has greatly facilitated such sutures. The ends of the vessel to be sutured are first united by three tension sutures of fine silk, inserted at equidistant points on its circumference. Traction upon these sutures approximates the edges of the vessel and renders the application of a continuous suture comparatively easy. In his original communication Carrel recommended avoiding the intima, where possible, but in his later experiments the sutures have included the entire thickness of the vessel wall. He has made no systematic study of the circular suture of divided arteries and veins but by applying his method to arterio-venous anastomoses and the transplantation of vessels and organs has obtained brilliant results.[4]

In 1903 an article by Jensen (40) on the circular suture of blood vessels, which was awarded a gold medal by the University of Copenhagen, was published. In this very complete and interesting article Jensen describes the various methods for uniting completely divided vessels which had been used up to that time and gives a critical review of the results obtained with them. Jensen's own experiments in which bone protheses, the magnesium protheses of Payr, and the various suture methods were tried on the vessels—mostly the internal jugular veins and carotid arteries—of horses and goats, were undertaken with a view to solving the following questions: (a) Why does thrombosis occur so often? (b) in how far does this or that method offer a better guarantee against thrombus formation?

Of three arteries united by Murphy's method two became completely thrombosed and one remained unobstructed; of three united by invagination over protheses of bone, in two the lumen was much narrowed and in the other almost obliterated; of twelve united by sutures seven were thrombosed, three were more or less constricted, and two were neither thrombosed nor constricted.

Ten veins were united by various protheses; of these eight became completely occluded and two remained patent but partly occluded. Seven veins were united by sutures; of these four were thrombosed, two more or less constricted and one neither thrombosed nor constricted.

From these results which are not very encouraging, Jensen rejects protheses and concludes that the best method of uniting completely divided vessels is to insert two or three simple interrupted or U-shaped sutures and join them by continuous sutures. He prefers silk to catgut and allows the suture to include the entire thickness of the vessel wall. He thinks thrombosis is due chiefly to infection with pathogenic organisms and says, "If we accept infection as the only cause of thrombus formation we have the best explanation of the capriciousness of the results of the experiments. This agrees also with the fact that sutures not involving the intima are more likely to succeed, for infection of the lumen is more difficult if the suture does not enter it."

In an extensive article published in 1903 Höpfner (30) gives statistics of the results of the ligation of large arteries and veins in man and thus points out the need of a practical method for uniting completely divided vessels. He then gives a history of the lateral and circular suture of vessels in animals and man. He experimented with the circular suture of vessels, vessel implantation and transplantation, and the replantation of amputated extremities, using the magnesium protheses of Payr.

Of six arteries united by this method, two became thrombosed and four remained unobstructed, three of these being examined eight days after operation and one four weeks after operation. The experiments with transplantation and implantation of vessels and the replantation of amputated extremities will be described later.

In 1903 Amberg (47) experimented with the circular suture of arteries in horses and large dogs, using the carotids, femorals, and abdominal aorta. After dividing the arteries, the ends were split longitudinally for a distance of 3 to 4 mm. so that the edges could be everted after the manner of flanges which were then sutured together intima to intima. His experiments were not very successful, for in only three of the six cases was the lumen entirely preserved. In one there was a mural thrombus and in the remaining two complete thrombosis and secondary hæmorrhage occurred.

Hubbard (48) in 1903 made several experiments with the lateral and termino-lateral anastomosis of the carotids of dogs. Of eight anastomoses all were thrombosed except two, and in these the lumen was almost completely obliterated.

In 1903 De Gaetano (49) tried on dogs a new method for the transverse suture of arteries. He placed a small spindle-shaped glass bobbin in the lumen of the vessel and applied the suture over the bobbin which was removed when the suture was nearly completed. This is said to greatly facilitate the suture. I have not been able to consult the original article and therefore cannot give the results of the individual experiments. According to De Gaetano histological examination of the specimens four months after suture showed a complete restitution of all of the elements of the vessel wall, including the elastic fibers.

In an article published in 1903 Reinsholm (41) presents an exhaustive study of the various methods for uniting large blood vessels and then gives the results of his own experiments with these methods. He thinks union with sutures is the best method and that the sutures, which should be of catgut, should not include the intima but a sufficiently firm portion of the vessel wall. I am sorry that I have been unable to consult his original article.

[4] Vid. infra.

In an article published in 1903 Chérie-Lignière (50) reviews the various methods of arterial suture and concludes that the simple suture is only applicable to longitudinal wounds and not to transverse wounds. He describes the Payr method in detail and reports his own experiments with this method. Of six cases in which the arteries of dogs and donkeys were thus united, in four the results were good, in two there was secondary hæmorrhage, once due to necrosis, once to infection. The magnesium cylinders were absorbed in 20 days. Secondary hæmorrhage is prevented by strict asepsis and the isolation of only a short stretch of vessel.

In 1903 Lejars (51) recommends the suture in longitudinal wounds of large arteries provided the operative field is aseptic, but if more than one-half the circumference is divided he thinks ligation is advisable, for after suture in such cases narrowing of the vessel lumen, secondary hæmorrhage, and sometimes peripheral embolism is to be feared.

According to Garré (23) the fact that the sutures can enter the lumen without danger of thrombosis as shown by Dörfler and others, greatly facilitates arterial suture. He advises the use of silk instead of catgut. The silk sutures are quickly covered with fibrin over which the endothelium soon grows.

In 1906 Dorrance[5] reported three cases of complete transverse suture of arteries in animals, in which he used a continuous mattress suture, whipping over the everted edges of the artery after the mattress suture was completed. In two cases the lumen remained unobstructed, in the other complete thrombosis occurred.

The circular suture of veins.—As compared with arteries very few experiments have been made with the circular suture of veins. This is probably due to the fact that the danger of gangrene following the ligation of large veins is, as a rule, less than that following the ligation of the corresponding arteries.

V. Hirsch[6] is said to have successfully sutured the completely divided femoral and jugular veins of dogs in 1881. Murphy in 1897 united the divided jugular vein of a sheep by means of a continuous suture of fine silk, the lumen of the vessel being considerably narrowed by the suture. The vein was examined 28 days later and found to be occluded by adhesion at the line of suture, but no thrombus was present.

In an article published in 1901 Clermont (17) gives an historical review of venous suture and reports his experiments with the lateral and circular suture of veins. The latter were limited to two sutures of the divided inferior vena cava: In one case the ends of the vessel were united by a continuous mattress suture of fine silk, which everted the edges of the vessel and approximated intima to intima; the union was completed by suturing the everted edges together with a continuous whip-stitch of the same material. The vessel was examined a month later and its lumen found to be perfectly smooth and unobstructed. In the other case he invaginated the peripheral end a few mm. into the central and fastened them thus with fine silk sutures which were allowed to enter the lumen. When examined a month later the vein was found to be patent, but greatly contracted. From these experiments and those with the lateral suture of veins, Clermont concluded that the first method is the best for suturing veins.

Payr (36) claims to have obtained excellent results in the union of veins by means of his magnesium protheses, which are applied to veins just as to arteries, except that with veins the peripheral is invaginated into the central end. The method is said to be more easily applied to veins than to arteries, for their walls are thinner and therefore more readily stretched. Here again Payr fails to give the number of his experiments or any exact description thereof.

In 1903 Jensen (40) made 17 experiments with the union of completely divided veins, using the simple suture in seven cases and protheses of various kinds in ten. Of the seven simple sutures four remained patent; of the ten cases in which protheses were used, eight became completely thrombosed and two remained patent. In six of the sutures the following method was used: After inserting two or three tension sutures, a continuous suture including the entire thickness of the vessel wall was applied. In the other case mattress sutures were used. In only two cases was catgut employed and in both thrombosis occurred. Of the ten cases in which protheses were employed, the cylindrical rings recommended by Payr were used in seven, but in only three of these were the rings made of magnesium, the others being made of bone or decalcified bone.

The circular suture of arteries and veins in man.—Cases of suture of completely divided vessels in man have been reported by Murphy, Djemil Pascha, Krause, Kümmell, Payr, Brougham, and probably others.

In 1897 Murphy (10) reported the following case: On September 19, 1896, a young man received a bullet wound in Scarpa's triangle just below Poupart's ligament. When he was first seen by Murphy on October 4, there was a marked thrill and loud bruit in this region and the pulsation in the popliteal and dorsalis pedis arteries was scarcely perceptible. At the operation on October 7, a penetrating wound was found in the femoral artery, which was almost divided, and also a small wound in the femoral vein. After closing the wound in the vein the artery was resected and united by the invagination method, the central end being invaginated into the distal for about one-third of an inch. On removing the clamps there was no leakage and pulsation immediately reappeared in the artery below the anastomosis. There was no disturbance of the circulation of the leg and the patient made a good recovery.

At the International Medical Congress in Moscow in 1897 Djemil Pascha (52) reported two cases of injury of the axillary artery treated successfully by Murphy's invagination method.

Krause (53) in 1900 reported this case in which he resected both the femoral artery and vein: In operating upon a woman, 55 years of age, for a carcinoma, the femoral vessels were found to be involved to such an extent that it was neces-

[5] Vid. supra.
[6] Cit. by Clermont.

sary to resect a portion of them. With the leg strongly flexed the ends of the vessels were then invaginated and fastened thus with sutures which did not involve the intima. Immediately after the operation pulsation could be felt in the artery distal to the suture; the leg had to be amputated later on account of gangrene.

In 1900 Kümmell (54) reported two cases, in one of which he anastomosed the femoral artery, in the other the femoral vein. In removing a carcinoma of the glands of the groin the femoral artery was found to be involved to such an extent that it was necessary to resect 5 cm. of this vessel. This was done in the following manner: After freeing the vessel above and below and applying clamps armed with rubber, the diseased portion was removed and, with the leg flexed at the hip, the central end of the vessel was invaginated ½ cm. into the distal and sutured with fine silk which did not include the intima. This suture was reinforced by a second layer of sutures which included only the adventitia. After a short time distinct pulsation could be felt in the popliteal artery. The carcinoma recurred in a few weeks and death followed in four months; at the autopsy, unfortunately, nothing could be seen of the suture, for the vessel was completely destroyed by the growth.

In the second case it was necessary to resect 2 cm. of the femoral vein, likewise on account of involvement in malignant growth. The ends of the vein were united by means of a continuous suture of fine silk which doubtless penetrated the intima. After removing the clamps the circulation in the leg was reestablished, and the patient made a good recovery.

In 1901 Payr (55) had an opportunity to try his method in man: In extirpating carcinomatous glands of the groin 4.5 cm. of the femoral vein was removed on account of involvement in the growth. The ends of the vessel were united by invagination over a magnesium prothesis after his method. The patient died three days later of pneumonia and examination showed that the lumen of the vein was fully preserved.

In 1906 Brougham (56) reported the following case: A man, 39 years of age, received a stab wound which almost completely divided the axillary artery and vein. The vein was ligated, but the division of the artery was completed, and the ends united by invagination after Murphy's method. The patient made an uneventful recovery.

Remarks.—What has been said above, in discussing the external suture of vessels, regarding suture materials, the means of provisional hæmostasis, the question as to whether the suture should or should not penetrate the intima, the need of a perfect aseptic technic, etc., applies equally well to the circular suture.

The methods recommended for uniting completely severed vessels may in general be divided in two classes: (a) Those in which the simple suture is used; (b) those in which mechanical aids are employed.

The suture has been applied in various forms; some have used simple interrupted sutures and mattress sutures, others the continuous suture; some include all the coats of the vessel in the suture, others try to avoid the intima, which in veins is almost an impossibility. Murphy recommends uniting completely divided vessels by invaginating one end a short distance into the other and fixing them thus with sutures.

The mechanical aids may be divided into the extra-vasal and endo-vasal. Among the former may be mentioned various clamps, decalcified bone and ivory rings, sheaths made of sections of other arteries or veins, aluminum rings, magnesium rings, etc. The most important of these are the magnesium rings or protheses of Payr, by means of which the ends of the vessel are so invaginated that intima is approximated to intima. Among the endo-vasal aids we may mention the glass cylinders of Abbe and Gluck, the caramel cylinders of Carrel and the glass bobbins of De Gaetano. These are of no importance clinically, but are of historical interest.

Although the results of the application of the invagination methods of Murphy and Payr to vessels in man have proven very gratifying, I cannot but feel in the light of the animal experiments of Carrel, Jensen, myself, and others, that the simple suture is preferable to these more complicated procedures. The results obtained in animals by Carrel and myself have been, barring the cases in which infection occurred, almost ideal and seem to demonstrate conclusively that the sutures can penetrate the intima with impunity. The method is simple, easy, and requires no mechanical aid. It seems to me that, just as in intestinal suture we approximate endothelium to endothelium, so in blood vessel suture it is advisable to approximate intima to intima. With Carrel's method traction upon the three primary sutures, during the application of the continuous suture, approximates intima to intima more or less accurately, but the apposition might be improved by substituting U-shaped sutures for the single traction sutures and then applying the continuous suture to the everted edges, as has been suggested by Jensen. The advantages obtained by this method might, however, except with large vessels, be counterbalanced by the constriction produced.

Arterio-Venous Anastomoses.

Circular or end-to-end arterio-venous anastomosis.—The first successful arterio-venous anastomsis was performed by Gluck (35) who united the carotid artery of a dog to the jugular vein by circular suture without thrombus formation. In 1902 Berard and Carrel divided the femoral artery in Scarpa's triangle and sutured the central end of the artery to the peripheral end of the saphenous vein. The anastomosis withstood the arterial pressure and the vein became distended and pulsated actively, but no physiological results were observed, as the animal died of infection two days after the operation. In the same year these experiments were continued by Carrel and Morel (57), who succeeded in anastomosing the central end of the carotid artery into the peripheral end of the external jugular vein without subsequent thrombus formation. Several weeks after the operation, when the animal was presented before the "Société nationale de médecine," the external jugular vein pulsated actively and a loud systolic murmur could be heard at the point of anastomosis. During

the several months the animal was under observation the results remained satisfactory.

In 1902 San Martin y Satrustegui (58) also experimented with the circular arterio-venous anastomosis. He made a series of 40 experiments on dogs, operating by preference in the groin, but also in the neck and other regions traversed by large blood vessels. The femoral vessels were separated and the central portion of the femoral vein ligated. Forceps were then applied to the central portion of the artery and the distal portion of the vein and the vessels divided; there was no bleeding from the distal end of the artery, although it was not clamped or otherwise occluded. The central end of the artery was then united to the distal end of the vein by invaginating the artery into the vein and suturing them with catgut. On removing the clamps the arterial blood flowed into the vein and the distal portion of the artery, which had remained bloodless during the operation, in 30 to 60 seconds after the current was turned on, began to carry fluid which looked like a mixture of arterial and venous blood, as though the current had been reversed. This end of the artery was then ligated, the wound closed, and the animal allowed to live. In later cases St. Martin saw the saphenous vein fill and change color as soon as the arterial blood was turned into the femoral vein.

All of the animals stood the operation well, except those whose peritoneum was invaded. One of the more vigorous dogs lived eight days with anastomosis of the carotid artery and jugular vein on both sides, death being due to hæmorrhage, or asphyxiation from enormous œdema of the neck. Few of the dogs had œdema, but in many there was a hæmorrage on the eighth day, which was often fatal. As to the cutaneous wound, it healed usually by first intention, sometimes there was a little suppuration, and in two or three cases a real phlegmon. The specimens were examined at periods varying from 48 hours to 20 days after the operation. The vessels were found completely obliterated by extensive thrombi, which, in the late examinations, were already organized. In one case the vessel remained pervious for two days, but in some instances coagulation took place even before the current was turned on.

In 1903 Exner (59) undertook certain experiments with the intention of studying the changes which veins undergo under arterial blood pressure. In four dogs he united the central end of the carotid artery to the peripheral end of the external jugular vein by means of the magnesium protheses of Payr. The wounds healed without reaction, but when examined two to six weeks after the operation, the vessels were found to be completely thrombosed. Höpfner (30) in 1903 also experimented with arterio-venous anastomoses, using the protheses of Payr. In all of his cases there was thrombus formation which he attributed to degeneration of the thin vein wall, produced by the high arterial tension.

In 1905 the experiments begun in France by Carrel and Morel were continued in this country by Carrel and Guthrie (60), (61), (62), (63), and, with improved technic, various arterio-venous anastomoses were done with very successful and interesting results. The technic is thus described by Carrel: "The threads and needles were the finest and strongest obtainable. The threads were sterilized in vaseline and applied when heavily coated with the same. The vessels were handled very gently and the endothelium was protected from drying by isotonic sodium chloride solution or by sterilized vaseline. No dangerous metallic forceps were used. The greatest care was exercised to obtain accurate and smooth approximation of the endothelium of the vessels. Finally, we developed a technic which is equally well adapted for arterio-arterial, veno-venous or arterio-venous anastomoses, and which yields uniformly successful results."

Circular or end-to-end arterio-venous anastomoses may be divided in two classes; viz., (a) uniterminal, and (b) biterminal arterio-venous anastomoses. The former will be discussed now, but the latter will be considered when we describe the implantation and transplantation of arteries and veins.

Concerning uniterminal anastomoses Carrel and Guthrie write as follows: "The termino-terminal anastomosis may be performed in nearly all cases even when the size of the vessels differs greatly. An artery may be easily united to a vein of twice its caliber. On the contrary, it is more difficult to unite a small vein to a large artery, for the venous wall is easily folded, while the artery on account of its thick walls is not. The more nearly similar the diameter of the vessels, the more easily successful anastomosis may be performed. When the vein is much larger than the artery and the consequent foldings of the vein in making the anastomosis are irregular, as may happen if the operation is performed without sufficient care, hæmorrhage occurs at the line of union. Fibrin may be deposited in the bottom of the foldings and in the miniature gaps occurring between the endothelial coats of the artery and vein. Therefore, when the difference in size of the artery and vein is too great, instead of end-to-end anastomosis, it is better to perform lateral implantation of the end of the vein into the wall of the artery.

"This termino-lateral arterio-venous anastomosis is more difficult than the former. It should be used only when the end-to-end anastomosis seems inadvisable, owing to the difference in size of the vessels or when the experimental result sought for indicates it. For instance, when a segment of intestine is transplanted into the neck for the purpose of establishing communication between the cut ends of the œsophagus, the end-to-end anastomosis of the intestinal vein to the jugular vein is impracticable, owing to the enormous difference in the size of the vessels. It then becomes necessary to make a lateral implantation of the end of the small vessel on the wall of the jugular vein. Or this lateral implantation is performed in order to obtain certain modifications of circulation, as, for example, lateral implantation of the central end of the external jugular vein on the common carotid artery, in order to diminish the amount of blood in the peripheral portion of the artery.

"Although the termino-lateral anastomosis is somewhat

more difficult than the end-to-end anastomosis, it is by no means impracticable on this account. By making a triangular opening larger than the lumen of the vein, through the wall of the artery, and taking care to have an accurate approximation of the endothelial surfaces of the vessels, the anastomosis is very satisfactory, as absolutely no blood escapes and no stenosis of the vein is produced.

"A third kind of anastomosis, more rarely used than the kinds above described, may also be mentioned. When the vein is exceedingly small, so small that a direct anastomosis is impossible, it is dissected as far as its junction with a larger vein. The wall of this vein around the mouth of the small vessel is then resected and grafted onto the wall of the artery.

"As previously stated this paper will deal mainly with the transplantation of veins onto arteries.

"There are six possible varieties of this operation, as the central end or the peripheral end of the vein may be united to the central end, the peripheral end or the wall of the artery. But as the anastomosis of the central end of the artery to the central end of the vein is practically the same in result as lateral implantation of the artery onto a vein, and as anastomosis of the peripheral end of the vein to the wall of the artery produces practically the same results as the anastomosis of the peripheral end of the vein to the central end of the artery, they do not deserve special mention. Four varieties only will therefore be described.

"1. *Union of the central end of the vein to the peripheral end of the artery.*—Anastomosis of the central end of the external jugular vein to the peripheral end of the common carotid artery is an example of this kind of operation. It produces a vessel composed in its upper portion of the carotid artery and in its lower portion of the external jugular vein. The pressure in this portion of the artery becomes lower than the normal blood pressure and the direction of the blood stream is reversed. The jugular carries toward the heart red, instead of dark blood. As a result, functionally, the carotid artery becomes a vein filled with red blood, being comparable in this respect to the pulmonary vein. It is probable that the wall of the artery undergoes marked anatomical changes. Owing to the lowering of the blood pressure, its wall may become thinner and the elastic and muscular layers modified, but at the present time we cannot go further into the point. But, as we have a dog in good health upon which this operation was performed nearly seven months ago, we shall subsequently be enabled to discuss it further.

"2. *Union of the central end of the vein to the wall of the artery.*—It is evident that after this operation a large part of the red blood of the artery returns toward the heart through the veins. In several cases the central end of the external jugular vein was united to the wall of the carotid artery. An abundant portion of the red blood flowed into the vein through the anastomosis with a strong thrill. The vein retained its venous functions, i. e., it conveyed blood toward the heart, but was filled with arterial blood. The artery also retained its normal functions, but its blood pressure was lowered. Tracings were taken, and they showed that after the establishment of the circulation through the anastomosis, the blood pressure in the artery is markedly diminished. This result is quite natural, for the lateral implantation of the central end of the jugular onto the wall of the carotid artery permits of a kind of continuous hæmorrhage from the carotid into the vein. When this operation is made on the jugular and the carotid it does not apparently alter the character of the circulation in general.

"3. *Union of the peripheral end of the vein to the peripheral end of the artery.*—This operation was performed on arteries having no, or very small collaterals. The result was the reversal of the circulation through the vein. The artery becomes filled with dark blood, venous in character. If, for instance, the peripheral end of the right renal vein be united to the peripheral end of the left renal artery, the dark blood from the right renal vein would flow through the left renal artery, the left kidney, the left renal vein and thus into the vena cava.

"4. *Union of the peripheral end of a vein to the central end of an artery.*—It is evident that, from a functional point of view, the operation transforms the vein into an artery. Several series of experiments were performed. The external or internal jugular or the thyroid veins were united to the carotid artery; the femoral or long saphenous veins to the femoral artery; and the inferior vena cava to the aorta.

"*The transplantation of the peripheral end of the external jugular vein onto the central end of the common carotid artery.*—The right external jugular vein was exposed, thoroughly dissected and cut near the root of the neck. Its peripheral end was inserted between the sterno mastoideus and the sterno hyoideus muscles and united behind the trachea to the central end of the left carotid artery. On release of the hæmostatic clamps, the vein became filled with red blood and pulsated like an artery, it being transformed from a functional standpoint into an external carotid artery. The vein is able immediately to perform the more important arterial functions. Its wall adequately supports the increased blood pressure. Even when the carotid artery is anastomosed to a more delicate vein, such as the internal jugular or thyroid, the sudden increasing of the pressure apparently does not injure the wall. In size the vein always appears to be very much enlarged. Clinically, this operation does not produce general or local symptoms if it deals only with vessels like the carotid and the external jugular vein. Even when the central end of the carotid is anastomosed to the peripheral end of the internal jugular vein the dog manifests no abnormal symptoms. A dog on which the operation was performed three months ago is now living and appears absolutely normal in all respects.

"In some cases the anastomosis may produce very dangerous effects. If, for instance, the central end of the abdominal aorta is united to the peripheral end of the vena cava, the circulation is immediately reversed in the lower part of the abdomen and the upper part of the inferior limbs, the valves stopping the blood from the lower portion of the latter for a

time. By degrees, however, they give way, and at the same time the animal may present symptoms of a very abundant hæmorrhage even becoming comatose. If at this stage the head be lowered and the posterior limbs elevated, it immediately regains consciousness, as evidenced by its cries and the ambulatory movements of the forelimbs. Post-mortem examination of such a case shows an enormous congestion of the veins below the level of the anastomosis, the animal dying apparently by hæmorrhage of the red blood into the venous system.

"After the operation the veins undergo a rapid structural modification, seemingly of an adaptive character, in order to meet the imposed arterial functions. The wall becomes thickened, owing, probably, to the increase of blood pressure, for if the vein has numerous collaterals, and consequently a relatively low blood pressure, the thickening is less rapid and marked. In a case of anastomosis of the central end of the carotid to the peripheral end of the jugular the specimen was taken five weeks after the operation. From the anastomosis to the first collaterals the wall was thicker than the wall of the carotid artery. Between the first and second collaterals the thickening was less marked. In the superior part of the neck, above numerous collaterals, the thickening was hardly apparent. When the vein has no collaterals, or when the collaterals are ligated, the transformation of the wall is very rapid and marked. After a few weeks the thyroid vein becomes very similar in size to the thyroid artery."

Carrel and Guthrie (64) claim to have produced an actual arteriosclerosis of an artery by suturing it into a relatively small vein. The macroscopic modifications of the artery are characterized by a slight retraction of its lumen and by a marked increase in the thickness and rigidity of its walls. The histological changes consist of an hypertrophy of the middle coat, which is due to an increase in the number and size of the muscle and elastic fibers and an hyperplasia of the interstitial connective tissue. The sclerosis of the adventitia may be regular or irregular. The same is true of the intimal sclerosis, which may present itself in the form of a regular thickening of the intima or may be much more marked in certain places than in others. The regions of greatest thickening of the intima and adventitia correspond to the places where the media is thinner. It seems that the arterial wall reacts first by an hypertrophy of the muscle layer and that the sclerosis of the intima and adventitia comes later. In a case observed three months and ten days after the operation the hypertrophy of the muscle was strongly marked, whereas, the intimal sclerosis was slight. In another case observed six months after operation the muscular hypertrophy was somewhat greater than in the preceding case, while the intimal sclerosis was much greater. No atheromatous lesions were observed.

When arterial tension is lowered by anastomosing an artery into a large vein the wall of the artery becomes thinner and its lumen larger. The muscular and elastic constituents of the medial coat diminish in number and volume.

Lateral arterio-venous anastomosis.—After his experiments with end-to-end arterio-venous anastomoses had failed, and arguing that arterio-venous aneurysms are well borne in man, San Martin y Satrustegui (58) in 1902 began to experiment with the lateral anastomosis of arteries and veins in goats. After opening the carotid artery and internal jugular vein in the neck, temporary hæmostasis was produced by small rubber tubing placed about the vessels at either end of the wound and openings 1 cm. long made in the vessels. The edges of the openings were then united by means of continuous sutures of fine silk, the posterior row of sutures apparently being placed from within the lumen. Two animals were thus operated upon and the result was said to be the same in both cases, though only one section was described. In this case which was examined three months after the operation, the carotid pulsated strongly and retained its original dimensions; the vein, however, was atrophied and almost empty of blood proximal to the anastomosis, but peripheral to the anastomosis was distended with dark blood and did not pulsate. The site of the anastomosis could hardly be determined by simple inspection, but seemed to correspond to the point where the vein suddenly became contracted. No opening could be demonstrated by injecting water into the vessels. From microscopic examination, however, St. Martin concluded that a small opening persisted.

Arterio-venous anastomoses in man.—From these experiments, although they could scarcely be called successful, St. Martin concluded that such an operation might be of value in treating gangrene due to arterial sclerosis. He tried it clinically in two cases. The first case was a man, 52 years of age, with gangrene of the toes extending onto the metatarsus. No pulsation could be felt in the dorsalis pedis, posterior tibial or even in the popliteal artery. The femoral pulsated strongly in Scarpa's triangle. An incision was made in Scarpa's triangle and the artery easily isolated, but the vein was freed with difficulty, being rather adherent. Temporary hæmostasis was produced by rubber tubes held with clamps. Openings 8 mm. long were then made in the vessels and a fairly satisfactory anastomosis obtained. After removing the ligatures the arterial blood passed through the artery to the limb, but the vein did not change color, either because the anastomotic opening was too small or because the walls of the vein had lost the little elasticity which they normally possess. The wound was closed and the gangrenous portion of the foot removed. The immediate result of the operation was fairly satisfactory; the pains became less, either because the gangrenous portion was removed, because the nerves had been separated from the vessel sheath to which they were quite adherent, or because, thanks to the anastomosis, the leg was better nourished. Unfortunately, this condition did not continue long and symptoms appeared which required amputation of the leg through the calf. The arteries were greatly sclerosed; the vein, however, appeared normal with the exception of some atrophy, probably from disuse. St. Martin thought the veins might have assumed the function of arteries if the operation had been done earlier and been more successful. Sometime later amputation through the middle of the

thigh resulted in death. The specimen showing the anastomosis was not examined, at least it is not described.

The other case was a man, 66 years old, who had gangrene of the toes. The same procedure was adopted as in the foregoing case. The artery and vein were so adherent to each other that, for hæmostasis, it was necessary to place the rubber bands about the two together. The nerve, however, was carefully separated. Very small openings were made in the artery and vein, which were united by continuous sutures. After removing the ligatures the vessels filled out, but the walls of the vein were so thick that one could not see whether arterial blood passed into the vein through the small wound. The wound in the groin was closed and the foot amputated. The patient made an uneventful recovery, but nothing is said of the subsequent behavior of the vessels.

In 1902 Jaboulay (67) reported the following case: A man, aged 47, had senile gangrene of the right foot which required amputation, first of the foot and then of the thigh. Sometime later gangrene began in his left foot and Jaboulay performed a lateral anastomosis of the femoral vessels in Scarpa's triangle. Thrombosis, which was attributed to the presence of an arterio-sclerotic placque, occurred at the site of suture, and it became necessary to amputate through the thigh.

In 1903 Gallois and Pinatelle (68), assistants of Jaboulay, reported this case and published the results of certain experiments, which they had made, to investigate the possibility of a reversal of the circulation in the head, arms, and legs. In order that such a reversal of circulation may take place they pointed out that the following obstacles must be overcome: (a) The valves; (b) the numerous venous anastomoses, which create short circuits and lower the blood pressure; (c) the resistance of the capillaries. Their experiments were done on the cadaver. A colored fluid was injected under pressure into the main vein of the member, but immediately returned by the other veins. After these were occluded it was impossible to force the fluid into the main vein, although considerable pressure was used. They concluded that, experimentally the circulation through the main vein of a limb, in a direction opposite to that of the normal current is prevented by the valves. They realized the fact, however, that, clinically, the valves can be forced and the current reversed in the veins, for they had observed cases of arterio-venous aneurysm, in which the veins of the limb, even at considerable distances from the aneurysm, were markedly dilated and pulsated actively.

Carrel and Guthrie (69) (70), who attribute the failure of the experiments of Gallois and Pinatelle to the fact that they operated upon the cadaver and not upon living tissues, which have a great adoptive power, seem to have proven that a reversal of the circulation in a limb of a dog is possible by establishing an end-to-end arterio-venous anastomosis. An experiment on a dog showed that three hours after a *termino-terminal* anastomosis of the central end of the femoral artery to the peripheral end of the femoral vein, the veins of the thigh, the leg, and the foot were filled with red blood, and that the dark blood returned to the heart through the arteries. They found that: (a) The valves prevent, at first, the reversal of the circulation in the veins; (b) after a short time the valves gradually give way and the red blood flows through the veins as far as the capillaries; (c) finally, it passes through the capillaries and the arteries are filled with dark blood. Probably the dark blood also returns from the capillaries toward the heart through some of the veins; (d) practically complete reversal of the circulation is established about three hours after the operation. However, when a *lateral* arterio-venous anastomosis has been done, the larger part of the arterial blood, instead of going toward the capillaries, returns to the heart through the central end of the vein and at the same time the arterial blood pressure is lowered. Experiments have shown that: (a) After a lateral arterio-venous anastomosis a very large portion of the red blood returns immediately toward the heart through the central end of the vein; (b) the peripheral portion of the vein and its branches are distended and pulsate, but the valves are not forced and the red blood does not circulate through them; (c) three hours after the operation all the valves are yet competent and no beginning of a reversal of the circulation can be detected.

If this be true very little can be expected from the treatment of senile gangrene by lateral arterio-venous anastomosis.

In 1906 Hubbard (71) reported the following case, in which he performed a crossed arterio-venous anastomosis of the femoral vessels for senile gangrene of the toes. The patient, a man 80 years old, was admitted to the hospital with dry gangrene of the middle toe of the right foot. There was a general arteriosclerosis and no pulsation could be felt in the dorsalis pedis of this foot. In spite of appropriate treatment the gangrene extended and involved the neighboring toes. Operation: The femoral vessels were exposed at the apex of Scarpa's triangle and a crossed arterio-venous anastomosis performed by invaginating the central end of the artery into the peripheral end of the vein and the peripheral end of the artery into the central end of the vein, and suturing them thus with fine Pagenstecher's thread. After the first anastomosis had been completed, and the means of provisional hæmostasis removed, the vein partially filled and pulsated slightly. During the manipulations the controlling tourniquet was pulled off the peripheral end of the artery and a considerable amount of dark, venous-looking blood escaped. It is hardly possible, however, that the circulation could have been reversed in such a short time. The cutaneous wound was closed with silk-worm gut and a plaster cast applied with the thigh flexed on the body to relieve tension on the vessels.

The patient made a good recovery, but the gangrene subsequently extended to the tarso-metatarsal joint, where a line of demarcation formed. At this time the author thought he was justified in making the following deductions: "Inasmuch as the circulation in the leg before operation was sufficiently poor to permit gangrene of the toes, and inasmuch as the femoral artery had been divided in Scarpa's triangle thus permitting collateral circulation only through the profunda, it was

fair to suppose that very little blood would have reached the lower leg through the collateral circulation, and that the gangrene would have rapidly involved the leg unless as a result of the operation the veins were carrying arterial blood." The lower portion of the leg and foot were amputated some time later. At this operation, which was performed without a tourniquet, the anterior and posterior tibial arteries were found to contain arterial blood, which spurted from the cut ends with fairly good force, and the veins did not appear to contain any arterial blood. These findings probably vitiate the previous deductions.

The application of arterio-venous anastomoses to the direct transfusion of blood.—Arterio-venous anastomoses have been employed by Crile and Dolley in the direct transfusion of blood in animals. From a large series of experiments they have drawn the following conclusions:

"Arteries and veins of varying sizes may be readily anastomosed by Carrel's method so as to be impervious to blood and free from clotting; the transference of blood from one animal to another is most definitely accomplished by anastomosing the proximal end of an artery of the donor into the proximal end of the vein of the donee: convenience may be the only consideration in the selection of the vessels to be anastomosed; the blood of one animal may be rapidly transfused to another; the blood of one dog is isotonic with that of another dog; if a dog be bled to the last drop of blood that will flow, and then an equal amount of blood be transfused from another, the transfused blood suffers no impairment by the blood or tissue of its new host, and, in turn, it causes no impairment; no hæmolysis is produced; and, finally, the transfused blood becomes a perfect substitute for the lost blood, and the factor of hæmorrhage may be eliminated."

Crile (72), who has applied the same method to various clinical cases, has obtained some brilliant results, especially with cases of hæmorrhage.

The author has transfused blood by this method in four cases, two of these being extensive burns, one a case of postoperative hæmorrhage in a jaundiced patient, and the fourth a case of pernicious anæmia. The results in these cases, which have not been studied as carefully as they should have been, were somewhat disappointing. I will now describe them in some detail.

CASE I.—The patient, a woman, 41 years of age, was admitted on February 5, 1907, with history and physical signs pointing to stones in the common duct. The jaundice, which had been present with varying intensity for ten weeks, became quite intense two weeks before she came to the hospital and remained so up to the time of her admission. Her coagulation time was considerably delayed, being 12½ minutes. At the operation on February 8, 1907, numerous small stones were found in the gall bladder and several large stones in the common duct, which could be removed through the greatly dilated cystic duct. A portion of the gall bladder was excised, the mucosa of the remaining portion being curetted and swabbed with pure carbolic acid. A tube was sutured into the cystic duct and an iodoform gauze pack placed down in the remains of the gall bladder. One bleeding point on the lesser omentum was ligated; otherwise the abdomen seemed perfectly dry.

A few hours after the operation the patient began to show signs of hæmorrhage which in six hours became quite alarming. The patient was pale, perspiring profusely and the pulse was 140 to the minute, and very weak. The dressings were saturated with blood and when these were removed a considerable ooze could be seen around the gauze drain. The wound was packed tightly with gauze, a tight binder applied to the abdomen, the legs bandaged and subcutaneous infusions of saline solution and other stimulants administered. In spite of this treatment the patient's condition steadily became worse until ten hours after the operation it was so critical that it was decided to do a direct transfusion of blood. At this time the patient was extremely pale, quite drowsy and the pulse could just be felt at the wrist, but could not be counted accurately. A man in one of the public wards kindly volunteered to donate the blood. Under cocaine anæthesia the left radial artery of the donor and the median basilic vein of the donee were exposed and, after applying small spring clamps armed with rubber, were divided. The proximal end of the artery of the donor was then sutured to the proximal end of the vein of the donee by Carrel's method. The suture was fairly satisfactory, there being no bleeding when the clamps were removed. The small size of the radial artery was, however, rather disappointing and during the operation the exposed portion of the vessel seemed to steadily contract in spite of the application of warm normal saline solution. The transfusion was continued for about 110 minutes. At the end of this time the vein was divided and the blood allowed to run into a receptacle for a few minutes. This blood was measured and, allowing for the time the stream had been turned on, it was estimated that the donee had received between seven and eight hundred cc. of blood. During the transfusion the condition of the donee improved somewhat but not so much as I had hoped and expected. After the operation she seemed brighter, said she felt better, her color was distinctly better and her pulse stronger but still quite rapid—140 to the minute. Hæmoglobin and blood pressure estimations were, unfortunately, not made. The donor showed the effects of the loss of blood very little, the blood pressure falling from 140 to 115.

The improved condition of the donee lasted only a short while. The hæmorrhage continued and she died five hours after the transfusion was completed. The abdominal wound was opened and the abdominal cavity found to contain 500+ cc. of blood.

Transfusions in the next two cases were undertaken, at the suggestion of Dr. Halsted, hoping that the blood pressure of the donees would be so increased by the transfusion that they could be bled from the opposite arm and the toxæmia, produced by the burn, thus combated.

CASE II.—The child, 3½ years old, was admitted on February 20, 1907, with an extensive superficial burn, involving the right half of the trunk, right arm, right side of the face, and, to a slight extent, the left arm and right leg. After being admitted to the hospital the condition of the patient became rapidly worse and in 48 hours it was critical; the pulse which on admission was 128 to the minute, was then 180, but of fair quality; the temperature, which on admission was 99°, had risen to 105°. The child was quite dull and hard to rouse. The following day the temperature was 103.8° and the pulse 170 to the minute, but its quality was poorer than on the previous day and the stupor was more pronounced, it being very difficult to rouse the child to take nourishment. In view of the toxic condition, high temperature, and rapid pulse it was decided to do a direct transfusion of blood, a relative of the patient consenting to give the blood. The operation was done practically as in the foregoing case,

except that, on account of the small size of the donee, the brachial vein was used instead of the basilica. The suture was quite satisfactory considering the small size of the vessels. On turning on the blood stream the vein became considerably distended and pulsated actively and it seemed as though the child was receiving a considerable amount of blood. Blood pressure observations, however, on the child showed no increase in pressure during the 30-40 minutes, during which the transfusion continued. After this time pulsation in the vein ceased and it was thought that thrombosis had occurred; accordingly, the vessels were ligated and that portion containing the suture was removed for examination. This examination revealed a small thrombus, adherent to the line of suture, which had probably occluded the vessel. The donor was little, if at all, affected by the bleeding. As said above, there was no increase in the blood pressure of the donee, so it was not considered wise to bleed from the opposite arm. Although it may be a case of *post hoc ergo propter hoc*, the child improved rapidly after the transfusion and is now (March 20, 1907), apparently on the road to recovery, though the temperature continues somewhat elevated.

Case III.—This patient, 4 years old, was admitted to the hospital with an extensive burn, involving the greater portion of the trunk, the face, the thighs, and parts of the arms. Her condition was critical and, in spite of appropriate treatment, steadily became worse, until, twelve hours after her admission, it was such that it was decided to do a transfusion of blood, intending, if possible, to raise the blood pressure to such an extent that the child might be bled from the opposite arm. At this time the child was pale, its extremities were cold and clammy, it was vomiting frequently and its pulse could hardly be felt. A man in one of the public wards kindly consented to give the blood and the operation was done exactly as in the preceding case. The anastomosis was very satisfactory. On removing the clamps the vein became distended and pulsated actively, and when pressure was made upon the vein it became so distended in the region of one of its valves that it looked as though it would burst. The transfusion was continued for 83 minutes, when the vein was divided and the blood found to be running at the rate of 4 cc. to the minute. It was thus estimated that the donee had received 332 cc. of blood. That portion of the vessels containing the suture was removed. On being opened it was found to be perfectly smooth and no thrombus was present. The condition of the child improved somewhat during the transfusion, its color improved and the quality of the pulse became such that it could be counted. The improvement was, however, disappointing and far from enough to warrant bleeding from the opposite arm. The donor showed the effects of the bleeding very little, his blood pressure falling from 120 to 105. The improvement of the child was of short duration, and it died about six hours after the transfusion was completed.

Case IV.—The fourth was an advanced case of pernicious anæmia, who had only 848,000 red blood cells to the cubic millimetre and whose hæmoglobin was reduced to 22 per cent. The transfusion was done largely in order to study the changes in the blood picture and to see how long the improved condition would last. The donor was a man with polycythæmia, whose red blood count was 8,712,000 and whose hæmoglobin was 123 per cent. In this case in order to avoid the contraction of the radial artery, if possible, it was not dissected out cleanly, as in the previous cases, but its venæ comites were left attached to it, except at the point where it was divided. In spite of this precaution, however, a good deal of contraction did occur. The artery of the donor was sutured to the proximal end of the median basilic vein of the donee as in the other cases. The suture was very satisfactory; no hæmorrhage occurred when the clamp was removed from the artery, the vein became distended and pulsated actively. After eighty minutes the vein was divided and the blood was found to be flowing at the rate of 16 cc. to the minute. It was thus estimated that the donee had received 1280 cc. of blood. At the end of the transfusion there was a perceptible flush to his face, conjunctivæ and finger nails, but there was no marked change in his subjective sensations. A blood count, made at this time, showed that the number of red cells had risen to 1,880,000 and the hæmoglobin to 33 per cent. The donor was not much affected by the bleeding; his blood pressure fell from 150 to 110, his red count to 6,912,000 and his hæmoglobin to 107 per cent.

The improved condition of the donee was of short duration. The daily blood examination showed a rapid diminution in the number of the red cells and amount of hæmoglobin; and in three days they were less than before the transfusion.

While all of these cases seemed to show some improvement as a result of the transfusion, the amount of improvement was disappointing; the cases, however, were very unfavorable ones. A striking feature of all of the experiments was the small size and great contraction of the radial arteries of the donors, which allowed a very slow rate of flow.

Implantation and Transplantation of Arteries and Veins.

In 1896 Briau and Jaboulay (32), experimenting upon animals, after having removed small sections of arteries reimplanted them by circular sutures. The vessels were examined three or four days after the operation, and in all the cases occluding thrombi were present. In an article published in 1898 Gluck (35) mentions having transplanted a portion of the jugular vein into the carotid artery of a dog. The section of vein healed in and there was no secondary hæmorrhage, but thrombosis occurred.

In 1903 Exner (59) experimented with the transplantation of blood vessels using the magnesium protheses of Payr. In six animals he transplanted portions of the external jugular vein into the carotid artery, but in all the cases thrombosis took place. In two dogs pieces of jugular vein, 4 cm. long, were transplanted into the opposite jugular vein, and in two other animals the same was done with the carotid arteries. In these cases also thrombosis was always present when the specimens were examined. Exner thought the failure of the latter experiments was due to the poor nourishment of the transplanted vessel, resulting from disturbance of the vasa vasorum.

In the same year Höpfner (30) performed some experiments with the implantation and transplantation of vessels, and obtained more or less successful results. He likewise employed the magnesium protheses of Payr. Of two cases, in which sections of the carotid were removed and reimplanted, one was successful when examined four weeks after the operation. In one dog a section of the carotid 3 cm. long was transplanted into the femoral artery and a section of the femoral of the same length into the carotid; when examined eight weeks later there was no thrombosis, almost no constriction of the vessels, and their intima was smooth. In another experiment a portion of the carotid of one animal was transplanted into the femoral of another animal, and a

portion of the femoral of the latter into the carotid of the former. The second experiment was successful, and the first was not, probably due to the fact that the wound in the neck healed per primam, whereas the wound in the groin healed by granulation. In 10 experiments, in which sections of veins were transplanted into arteries, although the technic was the same as in the other experiments and care was taken to have the valves of the veins point in the right direction, thrombosis always occurred. Höpfner concluded that such transplantations offer little prospect of being successful, for, when the current is turned on, there is a marked dilatation of the vein, and more or less stagnation of the blood, which leads to thrombus formation. In three experiments sections of vessels were transplanted from one animal species to another, but the result in all cases was negative.

Carrel and Guthrie, who, in this branch of vascular surgery also, have obtained the most remarkable results, speak of an autoplastic transplantation, when the section of vessel is taken from one vessel and transplanted into another vessel of the same animal, a homoplastic transplantation, when the section of vessel is taken from another animal of the same species, and a heteroplastic transplantation when it is taken from an animal of a different species. As a matter of fact, clinically it would be unnecessary to perform any but an autoplastic, transplantation, for we can easily extirpate a short section of vein without interfering with the general circulation.[1]

Transplantations may be (a) complete or (b) incomplete. In complete transplantations the segment of vessel is completely excised and then sutured between the cut ends of the other vessel. In incomplete transplantations the middle portion of the segment of vessel is allowed to remain attached to the surrounding tissues and to its branches; for example, a section of femoral vein can easily be isolated without disturbing its connection with the surrounding tissues and sutured between the cut ends of the accompanying femoral artery.

On removing the hæmostatic clamps, after transplanting a segment of vein into an artery, the segment of vein becomes distended with red blood until it is usually considerably larger than the artery, but, although they may be quite thin, its walls adequately support the arterial blood pressure. The pulsation in the vein is less marked than in the artery, for the vein is usually so distended that there is little excursion of the pulse wave. When the transplantation is incomplete and the segment of vein has branches, these branches do not immediately transmit arterial blood. At first they are filled with venous blood, which becomes displaced by the arterial blood as the valves are gradually forced. The branches then virtually become arteries.

[1] Since the preparation of this paper a very interesting article by Stich, Makkas, and Dowman has appeared in the "Beiträge zur klin. Chir.," Bd. 53, 1907, S. 113. Making use of the Carrel method of suture, the authors have obtained excellent results in the circular suture of arteries and the transplantation of arteries and veins. In a number of cases they have succeeded in transplanting sections of arteries from one animal species into another.

After the complete or incomplete transplantation of a segment of vein into an artery the walls of the vein undergo interesting structural changes. These changes have been studied by Carrel and Guthrie (73) who found the following conditions in a dog, examined 14 days after transplantation. The segment appeared as a dilated portion of the carotid artery, its external diameter being about twice as great as that of the artery. The specimen was opened longitudinally and the diameter of the lumen of the venous segment found to be greater than that of the artery, but less than it was at the time of operation. The endothelium was apparently normal, white, and glistening. The lines of union of the vessels were covered with healthy endothelium. After being cut the segment remained open like an artery. The wall appeared almost three times as thick as the wall of the artery and composed of an external and internal part. The two parts were strongly united, but could be separated by careful dissection. The internal part had the appearance of an arterial wall, its tissues on section being very light in color and very dense. The external part of the wall was almost four times as thick as the internal and its tissue was darker and less dense than that of the internal.

Microscopic examination.—Longitudinal sections were stained with hæmatoxylin and eosin, and Unna's stain for elastic fibers. The wall of the vein was greatly thickened. The intima appeared uniform, and its thickness was about like that of the artery. The tunica media of the venous segment appeared to consist of two layers, an inner, composed of muscle cells and longitudinal elastic fibers, and an outer, consisting mainly of coarse longitudinal, white, connective, and elastic fibers. In neither case were these layers as dense as the corresponding layers in the artery. At the anastomosis the muscular layer terminated mainly by sending elastic fibers to intermingle with similar fibers of the muscular coat of the artery, the muscle cells gradually disappearing. The adventitia also seemed to consist of two layers, an outer layer, composed chiefly of loose connective tissue continuous with the corresponding layer of the artery, and an inner layer, continuous with the outer portion of the granular mass lying between the middle and outer coats of the artery.

Replantation and Transplantation of Organs and Limbs.

The replantation of an organ or limb consists in removing it, replacing it, and re-establishing its circulation by vascular anastomoses. The transplantation of an organ or limb consists in its removal and transplantation into another animal or a different portion of the same animal, its circulation being re-established by vascular anastomoses.

In 1902 Ullmann (74) removed a dog's kidney and transplanted it into his neck, the renal artery being united to the carotid artery and the renal vein to the external jugular vein by means of Payr's protheses. The experiment was said to be successful, the kidney secreting normally after the operation. He does not state, however, how long this condition continued.

Three months after this report, Ullmann (75) reported having transplanted the kidney of one dog into another and the kidney of a dog into a goat. He exhibited the latter animal, and demonstrated the functionating kidney. When asked concerning the fate of the dog into whose neck the kidney had been transplanted, he did not say how long the animal had lived or how long the kidney had functioned. He said, however, that the kidney had been removed and on macroscopic examination several necrotic areas were seen; otherwise the kidney seemed normally nourished and had grown to the surrounding tissues.

In 1902 DecAstello (76) also reported experiments with the transplantation of kidneys. He extirpated the kidney of a large dog and transplanted a kidney from another dog into its place uniting the vessels by means of protheses. The animal lived 40 hours during which time 1200 cc. of urine was secreted. Death was due to hæmorrhage resulting from separation of the venous anastomosis.

In 1905 Floresco (77) reported certain experiments with the transplantation of kidneys. After several unsuccessful attempts he succeeded in extirpating the kidney of one dog and transplanting the kidney of another dog into its place the vessels being united by sutures. The end of the ureter was sutured into the skin incision. He does not give the ultimate results of the operation.

In one animal Floresco divided the nerves and ligated the lymphatic vessels of one kidney and extirpated the other kidney; in another animal he divided the nerves and anastomosed the renal vein of one kidney and removed the other kidney; and in a third animal he divided the nerves and anastomosed both the artery and vein of one kidney and removed the opposite kidney. All of the animals remained in good health and Floresco concluded that in the dog the renal vessels can be anastomosed, the nerves sectioned, the lymphatics ligated and the ureter anastomosed without the kidney ceasing to function and the dog lives after the other kidney is removed.

Since 1905 Carrel and Guthrie (63) have made numerous experiments with the replantation and transplantation of organs and have obtained some very interesting results. One of their first experiments along these lines was the extirpation and replantation of the thyroid gland with reversal of its circulation (78). The right thyroid gland of a dog was dissected out and all its vessels ligated except the superior thyroid artery and vein. These vessels were divided, the gland removed and then replaced, the circulation being reversed by suturing the artery to vein and vein to artery. Eleven days after the operation the wound was opened and the gland found to be somewhat enlarged, but its hue and consistency were normal. Twenty-five days after operation the condition seemed practically the same. No histological examination was made, however. By reversing the circulation of goitres in dogs they (79) claim to have produced a diminution in the size of the lobe operated upon and in one dog the goitre not only became smaller, but the general symptoms, referable to a hypothyroidism, largely disappeared. They think these phenomena were due to an augmentation of the circulation resulting from the reversal.

Carrel and Guthrie have used two methods of transplanting organs, *transplantation simple* and *transplantation en masse*.

The *transplantation simple* is the method which has been generally employed, but the objections to this method are that the nerves and their sympathetic ganglia are cut off from the organ and the veins are unduly exposed to injury, so that it is impossible to transplant such organs as the testicle and ovary by this method. To obviate these difficulties they developed the technic of *transplantation en masse*, which consists in extirpating the organ together with its surrounding connective tissues, its nerves and ganglia and its vessels with the corresponding segments of the large vessels from which they originate.

Making use of the simple method of transplantation Carrel and Guthrie have transplanted a heart, a loop of intestine, a kidney, and other organs into the neck. While the immediate result was, in most cases, satisfactory, the ultimate result was usually disappointing. A kidney which was thus transplanted, continued to function for some days (80) as thus described.

The kidney of a small dog was transplanted into the neck, the renal artery being sutured to the carotid artery, the renal vein to the external jugular vein and the ureter to the œsophagus. When examined three days later, the kidney was somewhat larger and its hue was darker than normal, but its consistency seemed normal and the pulsations of the renal artery were strong. The secretion of urine by the transplanted kidney was about five times more rapid than by the normal one. The intravenous injection of normal saline solution caused no change in the rate of secretion in the normal kidney, but markedly increased the rate of secretion in the transplanted organ. The constituents of the urines were similar, but the chlorides appeared more abundant in the urine from the transplanted kidney, while the organic sulphates, pigments, and urea were more abundant in the urine from the normal organ.

The *transplantation en masse* has been used by Carrel and Guthrie (81) (82) in the transplantation of kidneys and ovaries. The technic of these operations is thus described by them.

Both kidneys and the upper portion of the ureters were removed from a small dog, along with their vessels, nerves, nervous ganglia, the surrounding connective tissue, the suprarenal glands, the peritoneum, and the corresponding segments of the aorta and vena cava. The mass was placed in isotonic sodium chloride solution and later transplanted between the cut ends of the abdominal aorta and the inferior vena cava of a bitch. The circulation was reestablished after having been interrupted one hour and a half. Clear urine flowed abundantly from the transplanted ureters which were anastomosed to the normal ones. Both normal kidneys were then removed. The dog recovered rapidly from the operation and remained in good health for eight days, during which time she secreted large quantities of clear urine, which contained no blood and was about normal in composition, the only abnormal constitu-

ent being a small amount of coagulable proteid. The dog died on the tenth day as a result of intestinal obstruction, due to a localized peritonitis on the right side of the abdomen. The circulation of both kidneys was perfect, but there was an enormous hydronephrosis on one side.

Ovaries were transplanted as follows: The specimen, consisting of ovary and a part of the Fallopian tube, united to the segments of the aorta and vena cava by a cellulo-peritoneal ribbon and the ovarian vessels, was taken from one cat and transplanted into another cat from which the corresponding tissues had been removed. The operation is said to have been successful.

Their experiments with *heteroplastic transplantations of organs* were unsuccessful, and they think that, on account of cytolysis, such transplantations are not likely to be successful.

The replantation of amputated limbs.—In 1903 Höpfner (30) experimented with the amputation and replantation of the legs of dogs, uniting the femoral vessels in Scarpa's triangle by means of Payr's protheses. This was done in three animals. In the first case thrombosis occurred on the first day and gangrene followed; in the second case the circulation remained intact 11 days, when death occurred under chloroform, while the dressings were being changed; in the third case thrombosis occurred on the sixth day and gangrene resulted.

Carrel and Guthrie (83) have also made several experiments with the replantation of amputated legs of dogs, but none of these can be said to have been absolutely successful, for, although the circulation remained good for some days, obliteration of the vessels ultimately occurred.

AUTHOR'S EXPERIMENTS.

These experiments were begun with attempts to transplant the thyroid gland, making use of vascular anastomoses by Carrel's method. The attempts proved unsuccessful, so it was decided to apply this method to a series of arterial, venous, and arterio-venous sutures, with a view to determining in what percentage of cases we may expect a successful result.

The experiments were done on dogs of various sizes. When they could be obtained, large animals were used, but often it was necessary to make use of very small ones. The anæsthetic was ether, usually administered after a previous injection of one grain of morphine. The following technic was employed. After shaving a large area, the skin was cleaned with soap and water, permanganate of potash, oxalic acid and bichloride of mercury. The field of operation was then isolated with sterile towels and, after making the skin incision, sterile towels were clamped to the edges of the incision. The vessels were exposed, well freed and provisional hæmostasis produced by small spring clamps whose blades were armed with rubber. The vessels were then divided and prepared for suture by carefully removing the loose connective-tissue sheath about the ends of the vessel. This can be done very nicely by grasping the sheath with forceps, drawing it over the end of the vessel and clipping it off with scissors. The greatest care was exercised in handling the vessels, in order that they be injured as little as possible, and especial care was taken not to apply metallic forceps to the intima. Very fine (No. 16) straight needles and fine China bead silk were the suture materials employed, the thread being greased with or boiled in vaseline as suggested by Carrel. During the operation the drying of the vessels was prevented by the application of normal salt solution or sterile vaseline.

The vessel sutures were done according to Carrel's method. The vessel ends were first united by three interrupted sutures equidistant from each other on the circumference of the vessel, the sutures penetrating all the coats of the vessel. By traction upon these sutures the edges of the vessels were nicely approximated and a continuous suture easily applied. It is convenient to leave the needles attached to the long ends of the primary sutures and to use these ends for the continuous suture. On turning on the current there was seldom any leakage, and when it did occur a slight compression usually caused it to cease in a few minutes. The tissues over the vessel were approximated with fine silk sutures and the skin wound was closed with a subcuticular suture of the same material. The wounds were dressed with silver foil and when the operation was on the neck a crinoline bandage was applied. When the wound was in the groin, it was usually dressed with collodion; sometimes a crinoline bandage was applied, which was usually torn off by the animal within 24 hours. In this connection I should like to thank Dr. R. R. Norris, of Washington, D. C., for his kind assistance in carrying out many of these experiments.

PROTOCOLS OF EXPERIMENTS.

A. CIRCULAR SUTURE OF ARTERIES AND VEINS.

Expers. 4 and 5. Division and suture of both femoral arteries.—March 5, 1906.—Small black hound. The femoral arteries, 4-5 mm. in diameter, were divided and sutured. On removing clamps the left artery spurted at line of suture, two extra sutures being required to check bleeding. One extra suture required on the right side. Sutures only fairly satisfactory, approximation not perfect. No constriction. Active circulation. Subcutaneous tissues sutured with fine silk. Subcuticular skin suture. No dressing.

March 9, 1906.—Left wound seems to be healing well. Skin wound on right leg has broken open. Pulsation well felt in both popliteal arteries.

March 10, 1906.—Dog looks sick. Left wound looks only moderately clean. No pulsation felt in left popliteal artery. Right wound broken open. Pulsation felt in right popliteal artery.

March 13, 1906.—Dog died last night. Autopsy.—Left wound necrotic, though skin edges are still adherent. Hæmorrhage about artery, doubtless due to rupture at suture. Rupture not definitely located. Thrombus adherent to line of suture and occluding the lumen. Right wound broken open, granulating. Thrombus of same nature as on opposite side. Tissues of legs in good condition. No gangrene.

Expers. 7 and 8. Division and suture of the right common carotid and left external jugular.—March 12, 1906.—Small white and yellow shepherd dog. Incision on left side of neck. Left external jugular vein, 6 mm. in diameter, divided and sutured. Carrel's method. Fine white silk, greased with vaseline. Suture satisfactory. No leakage. No constriction of vein. Many su-

tures doubtless pierced intima. Subcutaneous tissues sutured with fine silk. Subcuticular silk suture.

New incision on right side of neck. Carotid artery, 4-5 mm. in diameter, divided. Arterial walls very thick, lumen 2 mm. in diameter. Attempt made to avoid intima. Suture satisfactory. No constriction of artery. Slight leakage. No extra suture required. Carrel's method, fine silk greased with vaseline. Wound closed as on opposite side. Silver foil dressing. Crinoline bandage.

March 21, 1906.—Dog in good condition. Bandage removed. Both wounds healed per primam.

March 31, 1906.—Pulsation felt in carotid distal to suture.

April 9, 1906.—Animal anæsthetized. Vein and artery exposed. Neither at all constricted. Slight ridge on outside of vessels indicating point of suture. Few adhesions about vessels. Pulsation of artery distal to suture as strong as that proximal to suture. Vein fills out when proximal end is compressed. Vessels ligated and portions containing sutures removed for examination. Wounds closed with silk. Crinoline bandage. On opening the artery, after removal, lumen found to be perfectly free, no constriction, intima absolutely smooth. No sutures visible. Lumen of vein also not constricted. Slight roughening of intima at a minute point in line of stuture. No thrombus present. Specimens saved in alcohol (Fig. 1).

Histological examination.—Paraffin sections were stained with hæmatoxylin and eosin, Van Gieson's stain, and Weigert's elastic tissue stain. The microscopic study is greatly disturbed by the presence of the sutures which occupy a comparatively large part of the sections. The sutures are surrounded by cellular masses containing numerous small round cells and epitheloid cells, and a few polymorphonuclear leucocytes and giant cells. The intima of the artery is smooth but considerably thickened, the small angle between the everted ends of the inner elastic membrane being filled with new-formed connective tissue derived from the intima. This tissue contains numerous fine elastic fibers. The scar is composed chiefly of connective tissue derived from the intima and adventitia, but the muscle fibers of the media are taking an active part in the restoration of the arterial wall. The elastic fibers of the media and adventitia have as yet invaded the scar very little but next to the scar are very abundant and occur in peculiar whorls. There is a considerable thickening of the adventitia and periadventitial tissues.

The sections of the vein were so distorted by the presence of the sutures that the microscopic examination was of no value.

Expers. 9 and 10. Division and suture of left common carotid and left external jugular.—March 12, 1906.—Small black and white terrier. Left common carotid, 4 mm. in diameter, exposed, divided and sutured by Carrel's method with fine white silk, greased with vaseline. Slight tension. Attempt made to avoid intima, only partially successful. Suture fairly satisfactory. Considerable leakage, controlled by one extra suture. No constriction produced by suture.

The left external jugular vein, 16 mm. in diameter, which was exposed through the same inicision, was divided and sutured in the same way, except that the intima was not avoided. Suture fairly satisfactory. Considerable constriction of vein. Tissues over vessels sutured with fine silk. Subcutaneous silk suture. Silver foil dressing. Crinoline bandage.

March 17, 1906.—Dog looks sick, doubtless due to presence of large abscess on side of chest, produced by hypodermic. Abscess opened.

March 21, 1906.—Bandage removed. Slight infection at middle of wound, seems superficial.

April 9, 1906.—Animal lively. Wound entirely healed. Pulsation felt in carotid distal to suture. External jugular fills on pressing vein proximal to suture.

April 23, 1906.—Dog anæsthetized. Vein and artery exposed. No constriction at points of suture. Few adhesions about vessels. Slight ridges on outside of vessels indicating lines of suture. Pulsation in artery distal to suture as strong as that proximal to suture. On being opened both artery and vein were absolutely smooth and free of thrombi. Specimens saved in alcohol (Fig. 2).

Expers. 11 and 12. Division and suture of right common carotid and left external jugular.—March 19, 1906.—Large brown setter. Left external jugular, 7 mm. in diameter, divided near middle of neck, sutured after Carrel's method with fine white silk, greased with vaseline. Some attempt made to avoid intima, not very successful. No leakage. Slight constriction of vein. Another incision on right side of neck. Carotid, 5 mm. in diameter, divided and sutured as above. Attempt to avoid intima, not very successful. Suture fairly satisfactory. No leakage. Tissues sutured over vessels with fine silk. Subcutaneous silk suture. Silver foil dressing. Crinoline bandage.

March 28, 1906.—Bandage removed. Wounds healed per primam. Condition of animal excellent.

March 31, 1906.—Pulsation felt in artery distal to anastomosis.

April 23, 1906.—Dog anæsthetized and vessels exposed in region of sutures. Result perfect. Conditions same as in expers. 9 and 10. One or two slight depressions in wall of artery at suture. Vein slightly roughened at one point. Absolutely no constriction of lumen. No thrombosis. Vessels excised and preserved in alcohol (Fig. 3). Wounds closed and animal saved.

Expers. 16 and 17. Division and suture of right common carotid and left external jugular.—April 2, 1906.—Large, curly-haired, black dog. Left external jugular, 7 mm. in diameter, divided and sutured by Carrel's method with fine white silk. Needles and sutures boiled in vaseline. Suture satisfactory. Some leakage which soon ceased without extra sutures. All coats included. Very slight constriction.

Another incision on right side of neck. Carotid, 6 mm. in diameter, divided and sutured as above. Considerable leakage, which soon ceased without extra sutures. All coats of vessel included in suture. No constriction. Tissues over vessels sutured with fine silk. Subcutaneous silk suture. Silver foil dressing. Crinoline bandage.

April 12, 1906.—Bandage removed. Wounds healed per primam.

May 5, 1906.—Dog in excellent condition, used in another experiment.

June 23, 1906.—Dog anæsthetized. Vessels exposed. No constriction of either vessel at anastomosis. Very few adhesions about vessels. On being opened intima of both vessels found to be quite smooth. Specimens saved in Kaiserling (Fig. 4).

Histological examination.—Paraffin sections were stained with hæmatoxylin and eosin, Van Gieson's stain, and Weigert's elastic tissue stain. The sutures have been almost entirely absorbed and replaced by delicate new-formed connective tissue. The remains of the sutures are surrounded by masses of small round cells, giant cells, and fibroblasts. The intima is smooth and lined by endothelial cells. Here, also, the angle between the everted ends of the inner elastic membrane is filled with connective tissue derived from the intima. No new-formed elastic fibers are seen in this tissue, owing, probably, to the poor staining. There is no regeneration of the inner elastic membrane. The musculature of the media seems entirely restored. The elastic fibers of the media and adventitia are poorly stained and appear to have invaded the scar only to a slight extent. The adventitia and periadventitial tissues are somewhat thickened.

Expers. 20 and 21. Division and suture of left external jugular and right common carotid.—April 23, 1906.—Medium-sized white and black hound. Left external jugular, 7 mm. in diameter, divided and sutured by Carrel's method. Fine white silk boiled in vaseline. All coats of vessel included in suture. No leakage. No constriction.

Right carotid divided and sutured in same manner. Slight

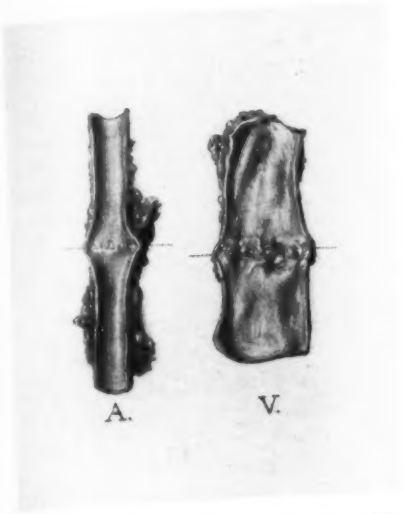

FIG. 1.—Circular suture of carotid artery and jugular vein, 28 days after operation.

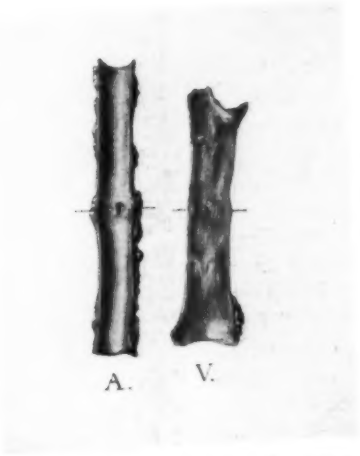

FIG. 2.—Circular suture of carotid artery and jugular vein, 42 days after operation.

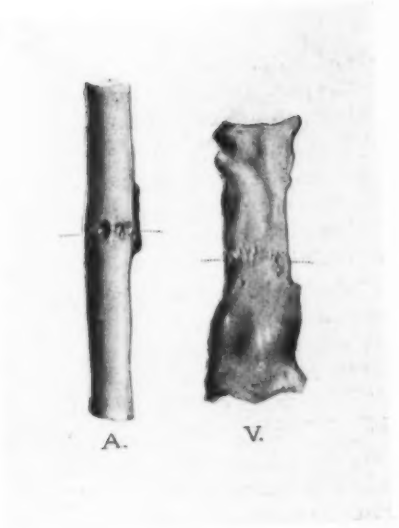

FIG. 3.—Circular suture of carotid artery and jugular vein, 35 days after operation.

FIG. 4.—Circular suture of carotid artery and jugular vein, 82 days after operation.

FIG. 5.—Circular suture of carotid artery and jugular vein, 48 days after operation.

FIG. 7.—Circular suture of carotid artery and jugular vein, 32 days after operation.

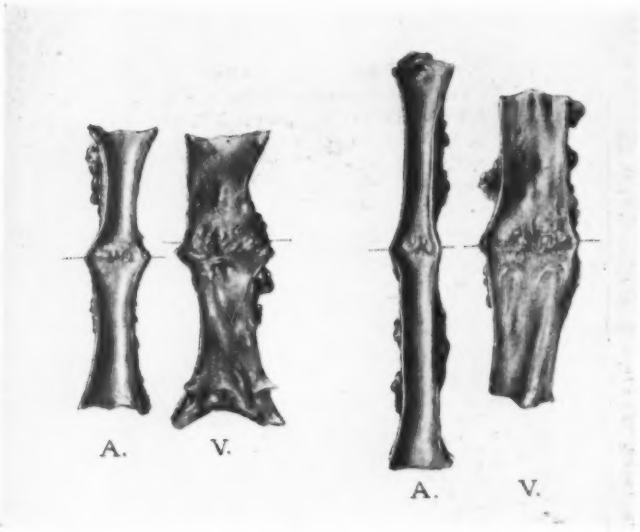

FIG. 6.—Circular suture of both carotid arteries and both jugular veins, 41 days after operation.

FIG. 8.—Circular suture of carotid artery and jugular vein, 26 days after operation.

FIG. 9.—Circular suture of both carotid arteries, 18 days after operation.

FIG. 10.—Circular suture of both carotid arteries and both jugular veins, 17 days after operation.

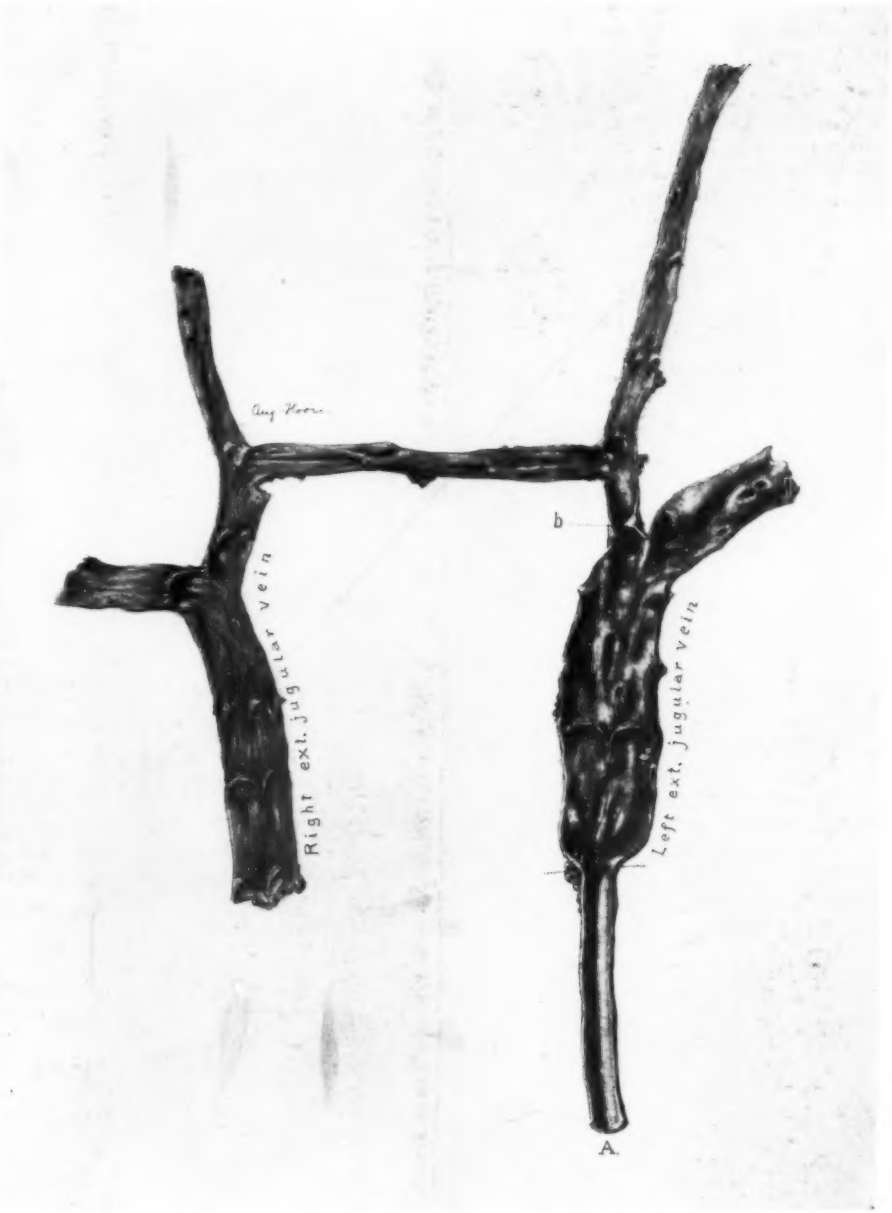

FIG. 11.—Circular anastomosis of the left common carotid artery and left external jugular vein, 4 months after operation. As a result of the arterial pressure this vein is much thickened and dilated. Small branch of vein occluded (b), probably due to valves being forced together and becoming adherent.

FIG. 12.—Circular anastomosis of carotid artery and jugular vein, 3 months after operation. Marked sclerosis of vein.

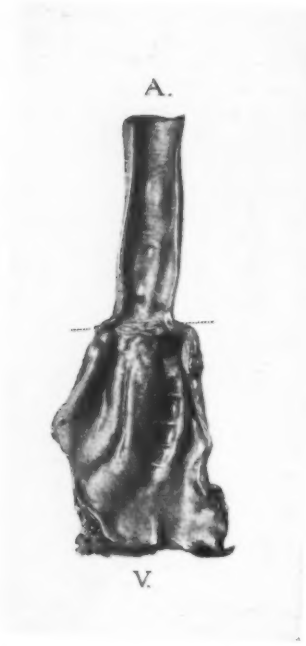

FIG. 13.—Circular anastomosis of femoral artery and vein, 3 months after operation. Marked thickening and dilatation of vein.

FIG. 14.—Circular anastomosis of carotid artery and jugular vein, 40 days after operation. Note thickening and dilatation of vein.

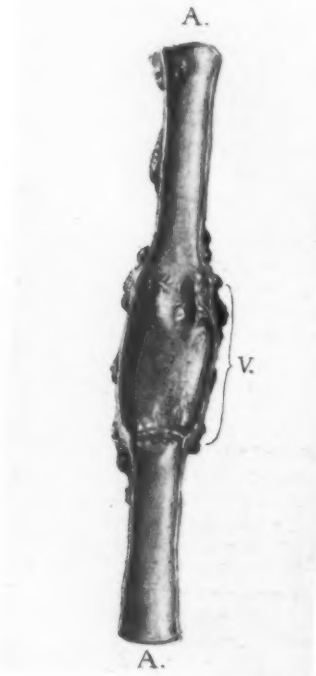

FIG. 15.—Transplantation of section of jugular vein into the carotid artery, 26 days after operation.

leakage, which soon ceased. No extra sutures required. Tissues sutured over vessels with fine silk. Subcutaneous silk suture. Silver foil dressing. Crinoline bandage.

May 3, 1906.—Bandage removed. Wounds healed per primam.

June 10, 1906.—Dog anæsthetized. Vessels exposed. Very few adhesions about vessels. Very slight constriction of vein. No constriction of artery. Pulsation in artery distal to suture as strong as that proximal to suture. Vessels opened. Very slight roughening of intima of vein. Intima of artery quite smooth. Specimens saved in Kaiserling (Fig. 5).

Expers. 22, 23, 24, and 25. Division and suture of both external jugulars and both common carotids.—April 30, 1906.—Medium-sized black cur. Both jugulars and carotids exposed, divided and sutured as in previous experiments 20 and 21. Jugulars 7 mm. in diameter. Carotids 5 mm. in diameter. Slight constriction of jugulars at point of suture. No leakage. Left carotid leaked somewhat, requiring one extra suture. Slight leakage from right carotid, which soon ceased. No constriction of arteries, pulsation distal to sutures being as strong as that proximal to sutures. Tissues sutured over vessels with fine silk. Subcutaneous silk sutures. Silver foil dressing. Crinoline bandage.

May 9, 1906.—Bandage removed. Wounds healed per primam.

June 10, 1906.—Dog in excellent condition. Anæsthetized. Both carotids and external jugulars exposed. Few adhesions about vessels near sutures. Pulsation in arteries distal to suture as strong as proximal to suture. Vessels removed and opened. Intima of arteries absolutely smooth. Left vein quite smooth. Intima of right vein slightly roughened by delicate spider-web-like bands, which might have been in process of being absorbed. Right artery and vein in Kaiserling. Left artery and vein in Zenker's fluid (Fig. 6).

Histological examination.—Paraffin sections of the artery were stained with hæmatoxylin and eosin, Van Gieson's stain, and Weigert's elastic tissue stain. The sutures are almost entirely absorbed and there are only a few small round cells and giant cells surrounding the remains of the sutures. The intima is smooth and lined by endothelial cells. The angle between the everted ends of the inner elastic membrane, which is not at all regenerated, is filled with a cellular connective tissue, derived from the intima. This tissue contains numerous fine elastic fibers, which toward the lumen are denser, thicker, are very wavy, and apparently take the place of the inner elastic membrane. With the exception of their elastic fibers the media and adventitia are practically restored. The elastic fibers at the edges of the scar are very abundant, form peculiar Medusa-head-like whorls, are evidently involving the scar and would doubtless be entirely regenerated. There is a considerable thickening of the periadventitial tissues.

Expers. 28 and 29. Division and suture of right common carotid and right external jugular.—May 9, 1906.—Medium-sized white terrier with brown spots. Right common carotid, 4-5 mm. in diameter, exposed, divided and sutured as in foregoing experiments. Suture only moderately satisfactory. Considerable leakage, which soon ceased. No constriction of artery. Pulsation of artery distal to suture as strong as that proximal to suture. Right external jugular, 6-8 mm. in diameter, divided and sutured. Suture very satisfactory, no leakage. Tissues approximated over vessels with fine silk sutures. Subcutaneous silk sutures. Silver foil dressing. Crinoline bandage.

May 23, 1906.—Bandage removed. Healing per primam. Dog in good condition.

June 10, 1906.—Dog in excellent condition. Anæsthetized and vessels exposed. Very few adhesions about vessels at lines of suture. Vein not at all constricted. Section removed and lumen exposed. No thrombus formation. Intima very slightly roughened at line of suture. No constriction of artery. Intima perfectly smooth. Absolutely no thrombus (Fig. 7). Dog killed. Specimen in Kaiserling.

Histological examination.—Paraffin sections of the artery were stained with hæmatoxylin and eosin, Van Gieson's stain, and Weigert's elastic tissue stain. The presence of the sutures distorts the sections and renders the microscopic study somewhat unsatisfactory. These sutures are surrounded by a few small round cells, epitheloid cells, and giant cells. The intima is smooth and lined by endothelial cells. As in the other cases, the angle between the everted ends of the inner elastic membrane is filled with a cellular fibrous tissue derived from the intima. This tissue contains numerous fine, new-formed elastic fibers which, toward the lumen, are thicker, denser, more wavy, and apparently take the place of the inner elastic membrane. While the scar is composed chiefly of connective tissue it is being rapidly invaded by muscle cells. The elastic fibers of the media and adventitia have as yet taken little part in the restoration of the arterial wall, but are very abundant next to the scar, occur in the peculiar whorls mentioned above, and are beginning to invade the scar. The adventitia is somewhat thickened and there is considerable thickening of the periadventitial tissues.

Expers. 31 and 32. Division and suture of left common carotid and left external jugular.—May 14, 1906.—Small black cur. Incision on left side of neck. Common carotid and external jugular exposed. Carotid, 4 mm. in diameter. Suture fairly satisfactory. Considerable leakage, which soon ceased. No extra sutures required. No constriction.

External jugular, 7 mm. in diameter. Suture satisfactory. No leakage. Slight constriction at suture. Some leakage into vein during suture, distal clamp holding poorly. Tissues over vessels sutured with fine silk. Subcutaneous silk suture. Silver foil dressing. Crinoline bandage.

May 23, 1906.—Bandage removed. Healing per primam. Dog in fairly good condition.

June 10, 1906.—Dog in good condition, anæsthetized, and vessels exposed. Very little scar formation about artery, somewhat more about vein. No constriction of artery. Section of artery containing suture removed. No constriction. Intima smooth. Vein slightly constricted at suture. Section of vein removed and lumen opened. No thrombus. Very slight roughening of intima at suture. Specimens saved in alcohol (Fig. 8). Dog killed.

Expers. 35, 36, 37, and 38. Division and suture of both common carotids and both external jugulars.—May 23, 1906.—Large white and black cur. Both carotids and both external jugulars exposed through openings on either side of the neck. Carotids, 5 mm. in diameter. Jugulars, 6-7 mm. in diameter. Vessels divided and sutured with silk after Carrel's method. Both arterial sutures quite satisfactory. There was considerable leakage, which, however, soon ceased without extra sutures. No constriction. Venous sutures quite satisfactory. Very slight constriction. No leakage. Tissues over vessels sutured with fine silk. Subcutaneous silk suture. Silver foil dressing. Crinoline bandage.

June 2, 1906.—Bandage removed. Wounds healed per primam.

June 10, 1906.—The dog, which had been sick for several days, died yesterday. Autopsy to-day: Vessels removed. No constriction of arteries. Intima smooth. Slight depression in intima at line of suture. Absolutely no thrombus formation. Specimens in Kaiserling (Fig. 9).

Left external jugular constricted and lumen occluded by small thrombus. Right external jugular also occluded. Organs of animal examined, apparently healthy. Death probably due to occlusion of both veins.

Expers. 41, 42, 43, and 44. Division and suture of both common carotids and both external jugulars.—June 1, 1906.—Medium-sized black and white cur. Both carotids and both external jugulars exposed through openings upon either side of the neck. Carotids, 5-6 mm. in diameter. Jugulars, 7-8 mm. in diameter. Ves-

sels divided and sutured after Carrel's method. Considerable leakage of left carotid requiring one extra suture. No constriction. Considerable leakage of right carotid also, but no extra suture was required. Suture of veins very satisfactory. No leakage. Very slight constriction. Subcutaneous silk sutures. Silver foil dressing. Crinoline bandage.

June 11, 1906.—Bandage removed. Wounds healed per primam. Dog in good condition.

June 18, 1906.—Dog has been sick for several days, died to-day. Autopsy: Vessels removed. Carotid sutures perfect. No constriction. Intima is quite smooth, but there is a slight depression at the line of suture. Lumen of right jugular considerably constricted by delicate cobweb-like bands. Left jugular occluded by stricture, probably due to organized thrombus, confined to line of suture. Specimens saved in Kaiserling (Fig. 10). Organs of dog apparently normal. Death probably due to poor venous circulation of head, following occlusion of veins.

B. Circular Arterio-venous Anastomoses.

Exper. 1. Circular anastomosis of the proximal end of the common carotid artery and the distal end of the external jugular vein.—February 21, 1906.—Small, curly-haired, brindle cur. The left common carotid artery, 5 mm. in diameter, and the left external jugular vein, 6-7 mm. in diameter, exposed and divided. Central end of carotid sutured to peripheral end of the jugular as in previous experiments. There was no leakage when the stream was turned on. The vein became distended until it was 8-9 mm. in diameter and pulsation could be felt in the vein near the head. Subcutaneous silver skin suture. Silver foil dressing. Crinoline bandage.

Feb. 24, 1906.—General condition good. Bandage removed. Wound looks clean. Whole left side of neck and head quite œdematous.

February 26, 1906.—Skin wound partly open. Marked pulsation in the jugular vein.

March 6, 1906.—Marked œdema of upper left neck.

March 21, 1906.—Wound almost healed. External jugular dilated and pulsating strongly.

April 3, 1906.—Dog seems well. Wound entirely healed. External jugular more than 1 cm. in diameter, pulsating vigorously. Loud systolic murmur heard over anastomosis and along the vein.

May 5, 1906.—Jugular as large as one's finger. Marked pulsation and loud murmur.

June 9, 1906.—Condition of animal good. Vein very large and thick. Murmur very loud.

June 26, 1906.—Dog anæsthetized and killed. Left external jugular vein distal to anastomosis much thickened and dilated, being perhaps 1 cm. in diameter. Right external jugular thinner and smaller. Both veins removed with connecting branch. On being opened after removal anastomosis was found to be perfect, the intima being absolutely smooth. The walls of the vein distal to the anastomoses were thickened and there were definite white placques in the intima. Slight dilatation behind the valves. Occlusion near beginning of small branch probably due to approximation of edges of valves. Thickening limited to unobstructed branch. Specimen in alcohol (Fig. 11).

Histological examination.—Paraffin sections of the vein a short distance distal to the anastomosis were stained with hæmatoxylin and eosin, Van Gieson's stain, and Weigert's elastic tissue stain. The wall of the vein is about twice as thick as that of the corresponding vein on the opposite side. The tissues of the vessel wall seem less dense than normal, probably owing to a certain amount of œdema. All the coats of the vein are thickened, but the most marked thickening is in the intima and media. The thickening of the intima is by no means uniform for, in the regions corresponding to the whitish placques, seen in the gross specimen, it is four times as thick as in some other places. The endothelial cells lining the intima are short, thick, and contain large nuclei. The intima is composed of a fairly cellular connective tissue, which in places stains more poorly and contains fewer nuclei than elsewhere, but there is no atheromatous degeneration. The thickening of the media, which seems to be due to an increase in the interstitial connective tissue as well as to an increase in the size and number of its muscle cells, is less marked where the thickening of the intima is extreme. The thickening of the adventitia, which is fairly well marked, also varies somewhat with that of the intima. There, also, seems to be some increase in the thickness and density of the periadventitial tissues.

The inner elastic membrane is well seen. There are numerous fine elastic fibers in the thickened intima, especially in its deeper layers near the inner elastic membrane. They are also quite abundant at the edges of the intimal placques, but are not nearly so numerous in the body of these placques. While the elastic fibers are diminished in number in both the media and adventitia, the diminution is much more marked in the former.

Exper. 13. Circular anastomosis of the proximal end of the common carotid artery and the distal end of the external jugular vein.—March 19, 1906.—Small white terrier with brown spots. Left common carotid, 4 mm. in diameter, and left external jugular, 6 mm. in diameter, exposed and divided. Central end of carotid sutured to distal end of jugular by Carrel's method as in preceding experiments. No attempt to avoid intima. Suture very satisfactory. No leakage. Marked dilatation and pulsation of vein after removing clamps. Subcutaneous silk suture. Silver foil dressing. Crinoline bandage.

March 28, 1906.—Bandage removed. Wound healed per primam. Strong pulsation in jugular vein. Thrill and bruit.

April 9, 1906.—There is a large swelling beneath lower jaw, more marked on the left, where fluctuation is felt, opened here and considerable pus evacuated. Marked pulsation in vein, systolic bruit and slight thrill.

May 5, 1906.—Marked thrill and loud murmur. Condition of dog good.

June 23, 1906.—Dog anæsthetized and left external jugular exposed. Vein pulsating vigorously, much dilated, 1.2 cm. in diameter, and apparently considerably thickened. On being opened, after removal, the walls of the vein were found to be twice as thick as those of the corresponding vein on the opposite side and the intima showed definite white placques, resembling those seen in arterio-sclerosis (Fig. 12). Specimen, along with opposite vein, saved in alcohol.

Histological examination.—Paraffin sections of the vein were stained with hematoxylin and eosin, Van Gieson's stain, and Weigert's elastic tissue stain. Microscopic examination of these sections shows practically the same conditions as in the previous experiment. While all the coats of the vessel are greatly thickened, the thickening of the intima, especially in the regions corresponding to the white placques seen in the gross specimen, is very marked. The endothelial cells lining the intima are rather short and thick, but not so much so as in the preceding experiment. The intimal thickening is composed of fibrous tissue fairly rich in cells. In certain places this tissue contains fewer nuclei and stains more poorly, but no atheroma is present. The well-marked thickening of the media is due to an increase in its connective tissue, as well as to an increase in the number and size of its muscle cells. Where the intima is thicker the muscle cells seem fewer and are often separated by a considerable amount of fibrous tissue. The thickening of the adventitia is also well marked. There is a considerable increase in the elastic fibers of the intima, especially in the deeper portions near the inner elastic membrane, where a net-work of fine fibers is seen. As a rule the elastic fibers seem somewhat less abundant in the thicker

placques, but at their edges and in their deeper layers numerous fine elastic fibers are seen apparently invading them. The elastic fibers of the media and adventitia are diminished, but the diminution is more marked in the former.

Exper. 14. Anastomosis of central end of femoral artery and distal end of femoral vein.—March 26, 1906.—Large, straight-haired, brown dog. Left femoral artery and vein exposed in Scarpa's triangle and divided. Artery, 5 mm. in diameter. Vein, 6-7 mm. in diameter. Peripheral end of artery and central end of vein ligated. Central end of artery sutured to peripheral end of vein as in preceding experiments. No leakage. On turning on the current the vein became considerably distended and pulsation could be felt 7-8 cm. below point of anastomosis. Subcutaneous silk suture. Silver foil dressing. Crinoline bandage.

March 28, 1906.—Leg very much swollen and œdematous, twice as large as the opposite one. Pulsation felt in vein 6 cm. beyond anastomosis. Dog looks rather sick.

March 31, 1906.—Dog lively, running around. Leg still much swollen. Wound apparently healing per primam. Loud systolic murmur along vein.

April 23, 1906.—Wound nicely healed. Loud murmur over vein. Marked pulsation felt in internal saphenous vein near the foot. Slight œdema of leg.

May 21, 1906.—Vein and its branches greatly dilated and pulsating actively. Marked thrill and loud murmur over anastomosis. Slight œdema of leg.

June 23, 1906.—Dog anæsthetized and anastomosis exposed. Vein distal to anastomosis pulsating actively, much thickened and dilated, being 1 cm. in diameter. The distal portion of the femoral artery was quite small and atrophic, apparently not performing the functions of a vein. On being opened after removal the anastomosis was seen to be quite smooth. Vein much thickened, intima thick and whitish (Fig. 13). Specimen in Kaiserling.

Exper. 45. Ligation of right femoral artery and vein.—April 9, 1906.—Small brown terrier. Right femoral artery and vein exposed in Scarpa's triangle and both ligated. Small branches of both vessels also tied. Wound closed with silk. No dressing.

April 20, 1906.—Wound healed per primam. Dog lively. No evidence of gangrene of leg.

This experiment was done as a control to those in which the central end of the femoral artery is sutured into the distal end of the femoral vein, to see whether simultaneous ligation of both femoral vessels will cause gangrene. Of course, one cannot draw definite conclusions from one experiment.

Exper. 19. Anastomosis of central end of femoral artery and distal end of femoral vein.—April 9, 1906.—Medium-sized white terrier with yellow spots. Right femoral vessels exposed in Scarpa's triangle and divided. Distal end of artery and proximal end of vein ligated. Central end of artery anastomosed to the distal end of vein. Slight leakage which soon ceased. On removing clamps vein became quite tense and pulsated vigorously. Subcutaneous silk suture. Silver foil dressing. Crinoline bandage.

April 11, 1906.—Dog lively. Little, if any, œdema of leg.

April 21, 1906.—Wound healed per primam. No pulsation felt in vein. No bruit heard. Thrombus doubtless present. Leg in good condition.

June 10, 1906.—Dog anæsthetized and killed. Anastomosis occluded by organized thrombus extending 1 cm. into artery and vein.

Exper. 26. Crossed anastomosis of femoral artery and vein.—May 2, 1906.—Medium-sized black and white cur. Right femoral vessels exposed in Scarpa's triangle, dissected free for a distance of 6 cm. Artery, 5 mm. in diameter. Vein, 6 mm. in diameter. Both vessels divided between clamps and the central end of the artery sutured to the distal end of the vein and the distal end of artery to the central end of vein. Sutures unsatisfactory on account of the great tension which necessitated flexion of the leg and rough handling of vessels. Thrombosis expected. When the clamps were removed the distal end of the vein became distended, pulsated, and assumed the functions of an artery. There was apparently no return of venous blood through the distal portion of the artery. Tissues over vessels approximated with fine silk. Subcutaneous silk suture. Silver foil dressing. Crinoline bandage. Three hours after operation marked pulsation could be felt in the internal saphenous vein near the foot.

May 3, 1906.—Dog died rather suddenly this morning, about 24 hours after operation. Anastomosis of central end of artery and distal end of vein occluded by thrombus, beginning sharply at suture and extending 1 cm. into vein, which was considerably dilated. Several very small thrombi adherent to the suture uniting the distal end of the artery and the central end of the vein. Organs examined, but nothing further found to account for death.

Exper. 30. Anastomosis of central end of femoral artery and distal end of femoral vein.—May 9, 1906.—Large brown setter. Left femoral vessels exposed. Distal end of artery and central end of vein ligated. Central end of artery sutured to distal end of vein by Carrel's method as in preceding experiments. Slight leakage, controlled by one extra suture. On turning on current the distal end of the vein bellied out and pulsated actively. Branches of vein gradually filled with arterial blood as the valves were forced. Two hours after operation pulsation was well felt in the internal saphenous vein near the foot. Tissues over vessels approximated with fine silk. Subcutaneous silk suture. Silver foil dressing. Collodion. Crinoline bandage.

May 14, 1906.—Dog looks sick. Entire left leg much swollen, quite cold. No pulsation felt in vein distal to suture.

May 15, 1906.—Dog dead. Autopsy: Left leg gangrenous. Infection about wound. Thrombus present, filling lumen of vein, beginning at suture and extending 1.5 cm. into vein.

Exper. 33. Circular anastomosis of left common carotid artery and left external jugular vein.—May 14, 1906.—Small yellow cur. Left external jugular and common carotid exposed. Vein, 6-7 mm. in diameter. Artery, 4-5 mm. in diameter. Vessels divided. Distal end of artery and proximal end of vein ligated. Proximal end of artery sutured to distal end of vein by Carrel's method. Considerable leakage, which soon ceased. No extra suture required. Marked dilatation and pulsation of vein when current was turned on. Subcutaneous silk suture. Silver foil dressing. Crinoline bandage.

May 23, 1906.—Healing per primam. Marked pulsation, thrill, and murmur over vein distal to suture.

June 23, 1906.—Animal in good condition. Active pulsation in vein. Loud murmur and marked thrill. Anæsthetized and specimen removed, along with corresponding portion of the opposite vein. Anastomosis perfect. Vein distal to suture considerably dilated and somewhat thickened. Specimen in Kaiserling (Fig. 14).

Histological examination.—Paraffin sections of the vein were stained with hæmatoxylin and eosin, Van Gieson's stain, and Weigert's elastic tissue stain. The changes in the vein are much less marked than those in the veins of experiments 1 and 13, owing not only to the shorter time elapsing after the operation, but probably to some extent to the large amount of periadventitial thickening in this case, which probably supported the venous wall. The intima which is more or less uniformly thickened, is lined by short, thick, almost cuboidal cells. The thickening of the intima is due to an increase in the subendothelial tissues. The thickening of the media is slight, but the muscle cells seem somewhat larger than normal. There is little, if any, thickening of the adventitia, but the periadventitial tissues are quite thick and dense. As yet there are no noticable changes in the distribution of the elastic tissue fibers.

Exper. 40. Circular anastomosis of the central end of the common carotid artery and the distal end of the external jugular vein.—May 28, 1906.—Very small white terrier with brown spots. Left external jugular and common carotid exposed. Artery, 4 mm. in diameter. Vein, 6 mm. in diameter. Distal end of carotid and proximal end of jugular ligated. Proximal end of carotid sutured to distal end of vein as in previous experiments. No leakage. Marked dilatation and pulsation of vein on removing clamps. Subcutaneous silk suture. Silver foil dressing. Crinoline bandage.

June 16, 1906.—Wound healed per primam. Vein much dilated and pulsating actively. Loud murmur and marked thrill present.

June 23, 1906.—Dog has escaped from paddock, is lost.

C. Lateral Arterio-venous Anastomosis.

Exper. 2. Lateral anastomosis of femoral artery and vein.—February 21, 1906.—Large black and brown hound. Left femoral vessels exposed in Scarpa's triangle. Artery, 5 mm. in diameter. Vein, 5-6 mm. in diameter. Numerous branches divided and ligated. Vessels thus well freed and clamps applied. Small oval openings 1 cm. long made in vessels. Four primary sutures applied and joined by continuous sutures. No leakage when clamps were removed. Vein became considerably dilated. Marked thrill could be felt in vein and loud murmur could be heard at some distance from animal. The red arterial stream could be seen through the thin walls of the vein, rushing into the vein and for the most part returning immediately to the heart with the venous stream. Wound closed with silk and subcutaneous silver. Silver foil dressing. Collodion. Crinoline bandage.

February 24, 1906.—General condition good. Considerable œdema of leg. Superficial veins dilated. Marked thrill.

February 26, 1906.—Wound healed per primam. Slight œdema of leg. Vein near anastomosis markedly dilated. Thrill seems less intense. Loud humming-top murmur can be heard as far as knee.

March 13, 1906.—Intense thrill. Loud murmur heard well below knee.

March 28, 1906.—Dog in good condition. No œdema of leg. Femoral vein moderately dilated. Branches of vein considerably dilated and pulsate. Marked thrill and loud humming-top murmur.

April 2, 1906.—Dog has disappeared, apparently stolen.

Exper. 15. Lateral anastomosis of femoral artery and vein.—March 26, 1906.—Large, curly-haired, brown dog, apparently very old. Left femoral vessels exposed. Artery, 6 mm. in diameter. Vein, 7 mm. in diameter. Several branches divided and ligated and vessels freed for a distance of 5-6 cm. Clamps applied. Oval openings about 8 mm. long made in vessels 5 cm. below Poupart's ligament. Four primary sutures applied. Continuous sutures between these as in previous experiment. All coats of artery and vein included in suture. No leakage. Slight constriction of artery. Vein became considerably distended. Marked thrill. Loud murmur, audible to naked ear. Tissues over vessels approximated with fine silk. Subcutaneous silk suture. Silver foil dressing. Collodion.

March 28, 1906.—General condition good. Considerable œdema of leg. Marked thrill and loud murmur present.

March 31, 1906.—Dog looks sick. Some bloody discharge from upper extremity of wound. Murmur and thrill present, but not so intense as at last note.

April 2, 1906.—Considerable bloody discharge from wound and some evidence of hæmatoma. Murmur can still be heard about point of anastomosis, but is much less distinct and apparently systolic in time. Very slight thrill.

April 3, 1906.—Dog very sick. Large hæmatoma present. Suture evidently leaking. Animal killed.

Exper. 18. Lateral anastomosis of femoral artery and vein.—April 9, 1906.—Medium-sized white and black hound bitch. Left femoral artery and vein exposed for a distance of 3-4 cm. and numerous branches ligated. Artery, 4 mm. in diameter. Vein, 5 mm. in diameter. Clamps applied. Small elliptical openings made in vessels 4 cm. below Poupart's ligament. Four tension sutures applied, connected by continuous sutures penetrating all the coats of the vessels. No leakage. Some constriction of artery, but pulsation of artery distal to suture remained strong. The arterial blood rushed into vein through the anastomosis and divided into two parts, the one returning to the heart, the other distending the vein for a short distance distal to the anastomosis. This distance gradually increased and the branches of the vein were filled with arterial blood as the valves were forced. Loud murmur and marked thrill. Wound closed with silk. Silver foil dressing. Crinoline bandage. Dog has distemper, does not look very strong.

April 11, 1906.—Dog lively. Very slight œdema of leg.

April 13, 1906.—Bandage removed. Wound looks clean. Loud murmur and marked thrill present.

April 14, 1906.—Murmur has disappeared. Thrombosis has probably occurred.

April 19, 1906.—Wound slightly infected, open at upper extremity.

May 5, 1906.—Wound healing by granulation. No thrill. No murmur.

June 23, 1906.—Dog anæsthetized and specimen removed. Femoral artery near anastomosis thrombosed for a distance of 2-2.5 cm. and converted into a fibrous cord. Vein patent. Lumen little, if at all, reduced in size. Slight depression in intima of vein indicating location of previous opening.

Exper. 27. Lateral anastomosis of femoral artery and vein.—May 2, 1906.—Large, curly-haired, black dog. Lateral anastomosis of left femoral vessels about 5 cm. below Poupart's ligament. Same technic as that used in foregoing experiment, except that the vein was not loosened up as much. Suture very satisfactory. No leakage. Considerable constriction of lumen of artery. When the current was turned on the bright arterial blood could be seen to enter the vein, the greater part returning immediately to the heart, the other making its way a short distance downward in the vein. Marked thrill. Loud murmur. Artery, 5 mm. in diameter. Vein, 6 mm. in diameter. Well-marked pulsation in artery distal to anastomosis. Tissues over vessels approximated with silk. Subcutaneous silk suture. Silver foil dressing. Crinoline bandage.

May 12, 1906.—Wound healed per primam. Marked thrill. Loud humming-top murmur.

June 1, 1906.—Thrill and murmur present, but not so marked as formerly.

June 23, 1906.—Thrill and murmur have disappeared. Dog anæsthetized and specimen removed. No thrombosis in either vessel. Intima smooth, with exception of slight depression indicating site of previous opening, which has closed. Anastomotic opening in this and foregoing case should have been made larger.

D. Transplantation of Arteries and Veins.

Exper. 3.—Excision and replantation of a section of the femoral artery.—March 5, 1906.—Small yellow cur. Left femoral artery, 4 mm. in diameter, exposed and several branches ligated. Section of artery, 2-2.5 cm. in length, removed and replanted, the sutures being done after Carrel's method. The excised portion contracted a great deal, the resulting tension making the suture rather difficult. Slight leakage, which soon ceased. Active circulation through artery after removal of clamps. On account of the considerable handling of the artery there seemed some danger of thrombosis. Tissues over vessels approximated with silk. Subcutaneous silk suture. No dressing.

March 13, 1906.—General condition of animal fairly good. Some swelling about wound, which is doubtless infected. Artery undoubtedly thrombosed. No pulsation felt.

March 17, 1906.—Wound entirely healed. No pulsation felt in femoral artery.

June 23, 1906.—Animal anæsthetized. Replanted artery thrombosed and converted into fibrous cord.

Exper. 6. Transplantation of a section of the external jugular vein into the femoral artery.—March 7, 1906.—Medium-sized white terrier with brown spots. Left external jugular vein exposed and 2.5 cm. thereof excised. Left femoral artery exposed and 1 cm. thereof excised. Vein, 6 mm. in diameter. Artery, 5 mm. in diameter. Section of vein sutured between ends of femoral artery by Carrel's method. When the arterial stream was turned on there was a slight leakage at the proximal suture, which was controlled by one extra suture. The vein became quite tense, about 8 mm. in diameter, and a water-hammer-like pulse could be felt in it. Circulation apparently active. Subcutaneous silk suture. No dressing.

March 9, 1906.—Transplanted vein feels very hard. No pulsation felt in it or in femoral artery below. Thrombosis probably present.

March 17, 1906.—Wound healed per primam. No pulsation in transplanted vein.

June 10, 1906.—Dog anæsthetized. Transplanted section of vein thrombosed and converted into fibrous cord.

Exper. 39. Transplantation of a section of external jugular vein into the common carotid artery.—May 28, 1906.—Small yellow cur. Incision in the left side of the neck. Common carotid, 4 mm. in diameter. External jugular, 6 mm. in diameter. Section of jugular vein 3 cm. long excised and transplanted between the cut ends of the carotid artery. On removing the clamps there was no leakage, the transplanted vein became considerably distended and pulsated actively, as did the common carotid artery distal to the suture. Slight thrill in vein. Subcutaneous silk culture. Silver foil dressing. Crinoline bandage.

June 10, 1906.—Dog in good condition. Bandage removed. Healing per primam. Pulsation felt in the transplanted vein.

June 23, 1906.—Dog anæsthetized. Transplanted vein exposed. Vein considerably dilated, 8-9 mm. in diameter, and thickened, pulsating vigorously. Specimen removed and opened. Both sutures quite smooth. Intima of vein whitish, evidently considerably thickened. Specimen in Kaiserling (Fig. 15).

Histological examination.—Sections of the vein were stained with hæmatoxylin and eosin, Van Gieson's stain, and Weigert's elastic tissue stain. The intima is lined by flat endothelial cells. The thickening of the intima, which is due to an increase in the subendothelial tissue, is fairly uniform. The media is considerably thickened, the thickening being due to an increase in the interstitial connective tissue rather than to any marked increase in the size or number of the muscle cells. While the adventitia is somewhat thickened there is a striking increase in the thickness and density of the periadventitial tissue. There seems to be an increase in the elastic tissue of the intima and a diminution in the elastic tissue of the media and adventitia.

E. Partial Occlusion of Vessels by Suture.

Exper. 34. Partial occlusion of the aorta.—May 14, 1906.—White and yellow shepherd. Abdominal incision. Aorta exposed a short distance above its bifurcation and its lumen narrowed by several through and through sutures. After the suture was completed the pulsation distal to the suture was considerably diminished. Wound closed with silk. No dressing.

May 23, 1906.—Dog in good condition. Healing per primam.

June 23, 1906.—Dog anæsthetized and specimen removed. Lumen of aorta diminished to half its normal size by the sutures. Many of the sutures projected into the lumen and were covered with a thin layer of organized fibrin. Specimen in Kaiserling.

F. Transplantation of Organs.[1]

Exper. 46. Transplantation of the thyroid gland.—January 31, 1906.—An incision was made on the left side of the neck of a large black and brown hound. The thyroid gland was dissected out, but was left attached to the carotid artery and to a vein, 3 mm. in diameter, leaving its lower pole. After being washed out with salt solution the gland was removed, along with a portion of the carotid artery and the small inferior vein, and transplanted into the neck of a somewhat smaller black and white cur, which had been prepared for it. Carotid was sutured to carotid and the small inferior vein to the internal jugular, which was of about the same size. The suture of the arteries was satisfactory, but the suture of the veins was quite unsatisfactory on account of their small size. Circulation of gland doubtful. Wound closed with interrupted silk sutures. No bandage.

February 19, 1906.—Dog well. Wound healed per primam. Weight, 33 pounds.

February 26, 1906.—Dog in good condition. Weight, 38 pounds.

May 3, 1906.—Dog anæsthetized and examined. Vessels thrombosed. No trace of gland found.

Exper. 47. Transplantation of the thyroid gland.—February 7, 1906.—Thyroid removed from the left side of the neck of a large, curly-haired, brown dog. Portion of carotid removed with the thyroid. There was a vein, 4 mm. in diameter, passing medially from the lower pole of the thyroid. This vein was used for subsequent suture. Gland washed out with salt solution and completely blanched, then transferred to a small white terrier already prepared. Carotid sutured to carotid; median vein to the external jugular. The carotid suture leaked somewhat, one extra suture being required. The clamp on the artery was now removed and there was considerable bleeding through the gland while the vein was being sutured. Venous suture fairly satisfactory in spite of the disproportion between the veins. The blood passed through into the external jugular as could be shown by the great distension of the external jugular when pressed upon. Skin closed with interrupted silk sutures. No bandage.

February 13, 1906.—Wound broken open. Gland lost. Thrombosed end of carotid seen in wound. Faulty asepsis.

Exper. 48. Transplantation of the thyroid gland.—February 14, 1906.—Thyroid removed from the left side of the neck of a very large, curly-haired, black dog. Internal jugular vein very small, 3-4 mm. in diameter. No median vein. The dog died shortly after the operation was begun. Gland hastily removed after death, along with portion of the common carotid and internal jugular. Gland washed clean and left in salt solution while the other dog was being prepared. Gland transferred into the neck of a small white terrier with brown spots on the head. Carotid sutured to carotid; internal jugular to external jugular. Suture in artery leaked considerably, requiring one or two extra sutures. Considerable disproportion in both arteries and veins, especially in the veins. Venous suture fairly satisfactory. Circulation in the gland good. Subcutaneous silver suture. Silver foil dressing. Crinoline bandage.

February 26, 1906.—Wound entirely healed. The dog is lively, but very thin. The transplanted thyroid can be easily felt.

March 13, 1906.—Dog still very thin. Transplanted thyroid can be readily palpated.

March 17, 1906.—Considerable swelling about the gland, soft and fluctuant.

March 21, 1906.—Dog anæsthetized and operated upon. Swelling found to be a collection of turbid fluid surrounded by scar

[1] These experiments were done by Dr. W. G. MacCallum and myself.

tissue. No remains of thyroid gland found. Small necrotic pieces of transplanted carotid present.

Exper. 49. Transplantation of the thyroid gland.—February 19, 1906.—Thyroid gland removed from the left side of the neck of a large brown dog, along with a portion of the carotid artery and median, inferior vein, which was fairly large, 4 mm. in diameter. Gland washed out with salt solution and transferred into the neck of a small white cur. Carotid sutured to carotid, the suture being quite satisfactory. Median vein sutured to the external jugular; venous suture unsatisfactory on account of the great disproportion in the size of the veins, did not allow very free passage of blood. Subcutaneous silver suture. Silver foil dressing. Crinoline bandage.

February 26, 1906.—Wound broken open, granulating well. Gland not exposed, muscles apparently having healed together over the gland.

March 3, 1906.—Dog anæsthetized. Large hæmatoma under wound in neck, doubtless due to rupture of the carotid suture. Thyroid doubtless necrotic, not found. Remains of transplanted vessels found, also soft and necrotic. No pus present.

Exper. 50. Transplantation of the thyroid gland.—February 26, 1906.—Thyroid gland along with portions of the carotid artery and a small vein leaving its lower pole removed from a large yellow setter, washed out with salt solution and transplanted into Scarpa's triangle of a small white terrier with black ear. Carotid artery sutured to the femoral artery and the inferior vein to the femoral vein. Sutures very satisfactory. No leakage. Circulation quite satisfactory for a time, the small arteries of the gland pulsating actively; later the circulation became more sluggish. Skin closed with interrupted silk sutures. Silver foil and collodion dressing.

March 3, 1906.—Dog anæsthetized. Left leg œdematous and gangrenous. Artery and veins of gland thrombosed, thrombi extending into the femoral vessels. Transplanted thyroid necrotic.

Exper. 51. Transplantation of the thyroid gland.—February 28, 1906.—Remaining thyroid removed from the neck of the large, curly-haired, brown dog used in experiment 47. Thyroid not hypertrophied. Portion of the carotid artery and inferior median vein, 3-4 mm. in diameter, removed with gland. Gland washed out with salt solution and transplanted into the abdomen of a small white cur with black spots. Carotid artery sutured to the common iliac artery and the median vein of the thyroid to the common iliac vein. Arterial suture fairly satisfactory. Slight constriction of the vein at the site of suture. Circulation in the gland quite active when the abdomen was closed.

March 10, 1906.—Dog seems well. Wound entirely healed with the exception of a small granulating sinus at its posterior extremity.

March 12, 1906.—Dog very sick. Considerable discharge of dark blood from the sinus mentioned above. Killed with chloroform and examined. Sinus found to lead down to a large cavity in the region of the transplanted thyroid, filled with blood-clot. Thyroid not found, doubtless very necrotic. Remains of thyroid vessels found, filled with thrombi extending into the iliac vessels. Tissues of leg in good condition, no gangrene.

Results.—The common carotid artery was sutured thirteen times. All of the sutures were perfectly successful and in no case was there the slightest evidence of thrombus formation. The femoral artery was sutured twice, thrombosis occurring both times as a result of wound infection. The external jugular vein was also sutured thirteen times, ten of the sutures being successful.

Microscopic examination of the arterial sutures at periods varying from twenty-eight to eighty-two days after the operation shows that there is a gradual restoration of the artery at the site of suture and that with the exception of the inner elastic membrane, all the elements of the vessel wall are probably regenerated. The sections of the thin-walled veins which were obtained were so distorted by the presence of the silk sutures that they were of little value for microscopic study.

The common carotid artery was sutured to the external jugular vein four times, all being successful. After the suture the veins became distended and pulsated vigorously; a marked thrill could be felt in the veins and a loud murmur heard over them. Examination of the veins one to three months after the operation showed a marked dilatation of these vessels, a thickening of their walls, and in some there were interesting placques in the intima, suggesting the changes seen in arterio-sclerosis. Microscopic examination of the walls of the veins revealed changes very analagous to those found in the walls of arterio-sclerotic arteries. In the vein of experiment 13 (see Fig. 12) the following condition was found: While all the coats of the vessel were greatly thickened, the thickening of the intima, especially in the regions corresponding to the white placques seen in the gross specimen, was very marked. The endothelial cells lining the intima were short and thick. The intimal thickening was composed of fibrous tissue fairly rich in cells. In certain places this tissue contained fewer nuclei and stained more poorly, but no atheroma was present. The thickening of the media was due to an increase in the interstitial connective tissue as well as to an increase in the size and number of its muscle cells. Where the intima was thicker the muscle cells seemed to be fewer and were separated by a considerable amount of connective tissue. The thickening of the adventitia was also well marked. There seemed to be a considerable increase in the elastic fibers of the intima, especially in the deeper portions near the inner elastic membrane, where a net-work of fine fibers was seen. In general, the elastic fibers seemed somewhat less abundant in the thicker placques, but at their edges and in their deeper layers numerous fine elastic fibers were seen, apparently invading them. The elastic fibers of the media and adventitia were diminished, but the diminution was more marked in the former.

The central end of the divided femoral artery was sutured to the distal end of the divided femoral vein four times. One case was successful; in the others thrombosis occurred. In the successful case the leg became very much swollen after the operation and in two days was twice as large as the opposite one. The swelling gradually subsided but never entirely disappeared. The femoral vein became much dilated and marked pulsation could be felt in the saphenous vein near the foot. Examination three months after the operation showed a marked dilatation and thickening of the wall of the vein. The distal portion of the femoral artery was small, atrophic, and did not seem to be performing the functions of a vein.

In four animals a lateral anastomosis of the femoral artery and vein was made. In all the cases the immediate result was

quite satisfactory; on turning on the blood stream there was no leakage, the vein became considerably distended, a thrill could be felt in it near the point of anastomosis and a humming-top murmur could be heard at some distance from the animal. The red arterial stream could be seen through the thin-walled vein, rushing into the vein and for the most part returning immediately to the heart. In only one of the animals, however, did the anastomosis remain patent, a marked thrill and loud murmur being present five weeks after the operation when the animal escaped from the paddock and was lost. In the second animal the murmur and thrill persisted for four weeks and then disappeared, examination a few weeks later showing that the anastomotic opening had healed, but that the vessels had remained patent. In the third animal, whose wound became infected, the thrill and murmur lasted only four days; examination two months later showed a thrombosis of the artery, the vein remaining unobstructed. In the fourth case the thrill and murmur persisted five or six days, death occurring on the eighth day after operation from secondary hæmorrhage.

Excision and replantation of a section of the femoral artery was done once, but thrombosis occurred. Transplantation of a section of vein into an artery was tried twice. In one instance a section of the external jugular vein was transplanted into the common carotid artery with perfect success. Examination of the specimen (see Fig. 15) twenty-six days after the operation showed considerable dilatation and thickening of the transplanted vein and the microscopic study of the vein revealed a condition very similar to that described above, resulting from the end to end anastomosis of the carotid artery and jugular vein. In the other case a section of the external jugular vein was transplanted into the femoral artery, but thrombosis resulted in a few days.

Transplantation of the thyroid gland was done six times, but none of these were successful. The failure of these experiments may be attributed to the small size of the inferior thyroid vein, whose diameter rarely exceeded two or three millimeters, and to the fact that the transplantations were undertaken before we had made any experiments with simple vascular sutures.

In reviewing our experiments we find that of thirty-one experiments upon the vessels of the neck twenty-eight were successful, whereas of twelve experiments upon the femoral vessels only two were entirely successful. This discrepancy is not difficult to explain. Wounds in the neck are inaccessible to the dog's teeth, and can be readily bandaged, the wounds being thus kept clean and dead space obliterated. In the groin, however, it is very difficult to apply a bandage which will remain in place, obliterating the large dead space which is so apt to be present and preventing movements of the leg which interfere materially with a successful vessel suture.

The results show conclusively that completely divided vessels can be sutured with almost uniform success, when the aseptic technic is good. The intima can be included in the suture with impunity, the application of the suture being thus greatly facilitated.

Nearly all experimenters with the suture of blood-vessels have called attention to the need of a very perfect technic. I wish also to emphasize this point, for I consider infection by far the most important factor in producing thrombosis after vascular sutures. I think, as Carrel does, that there may be minor grades of infection, which, although allowing per primam healing of the wound, may be sufficient to produce thrombosis of the sutured vessels.

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BOSTON MEDICINE ONE HUNDRED YEARS AGO AND A NOTABLE PHYSICIAN OF THE LAST CENTURY.[1]

By J. G. MUMFORD, M. D.

In 1807 but four young men were graduated in medicine from the Harvard school, and received the degree of M. B. Those were pleasant times in which to live in Boston. The town was still a small town, not yet raised to the dignity of a city—a town of 25,000 inhabitants, about a quarter the size of our modern Cambridge, or with a population one-twentieth of what Baltimore now contains. We have abundance of light on the life of the period. Men of letters were concerned in writing history, and the journals and epistles of the day abound in descriptive story. The Harvard Medical School was 25 years old, and the original three professors, John Warren, Benjamin Waterhouse, and Aaron Dexter still exercised their professorial functions. It was a time of comfort and activity in the commercial and academic worlds. Society was busy in charity, and spoke good will; while the temper of the people was not different from what it had been more than a hundred years earlier when Increase Mather wrote of Boston that "for charity, he might indeed speak it without flattery, this town hath not many equals on the face of the earth." Some fond optimists still maintain the boast.

In those days of 100 years ago, the respectable and influential people of the town—as the old writers call them—were actively exercised in forming and carrying on all sorts of educational, philanthropic, and literary enterprises, as their descendants do to this day. The Massachusetts Medical Society, the most potent and far-reaching of State medical societies, was making itself felt in the uplift of the profession, and among its active and important promoters were such well-known men as Holyoke, the two Warrens, Jackson, Gorham, and Jacob Bigelow; the Medical School was developing as an important department of Harvard University; the Massachusetts Historical Society was in the 14th year of its distinguished career; libraries such as the Columbian, the Anthology Reading Room—which subsequently became the Boston Atheneum—and the Boston Library Society were beginning to gather those great collections which to-day are the pride and solace of scholars; the Massachusetts Humane Society, the Massachusetts Charitable Association, the Charitable Mechanic Association, the Boston Dispensary, the Boston Female Asylum, and a dozen other cognate organizations were flour-

[1] Read before the Johns Hopkins Historical Club, February 11, 1907.

ishing in a vigorous young life. The Massachusetts General Hospital was in process of inception at this time, though 14 years were to elapse before it was opened to patients.

Writers tell of a charming society living in the midst of an unusually beautiful environment. The country of eastern Massachusetts was nearly 200 years settled, and in those days, before railroads and steamboats existed, when connection with other states was by post road and coasting vessels, Boston seemed a remote and detached town. It was then an important shipping port. The vessels of its merchants sailed for the old countries of Europe, the south seas, and India, so that it had built up within itself a rather self-centered population; a community old in years as American communities then went, with long-established customs, and a widely cultivated country, after the turmoil of the Revolution. Be it remembered of Boston society, as with the society of other ancient colonial towns, that the Revolution had put an end almost to the old time dignified life. Representative families, largely, were Tories, and left the country when Boston fell before the arms of Washington. A new society grew up and new men appeared as eminent citizens, so that it was not until a second generation began to develop that a renewing of the former stability became apparent. That was the condition in the early years of the last century. The Revolution and the infusion of new, restless, democratic persons into the affairs of the place, tinctured though such persons were with many of the ideas and prejudices of former times, developed an active, progressive and interesting assemblage of people. In 1807 the growth of the new West had hardly begun to take on that fury of interest and activity which characterized it in the next generation. The old States themselves were thinly settled still, and eastern Massachusetts, isolated and far removed from other great centers, went about its business in self-confident and thorough fashion.

There was one exception as yet to this self-confidence, and that exception was in the education of physicians. Massachusetts had always abounded in doctors. The medical profession was a favorite profession there in colonial days, but the best of the doctors had to look beyond the colony for their education. Many of them went to London and Edinburgh, but more flocked to the Philadelphia school. The foundation of the Harvard Medical School, in 1782, by no means put a stop to these Philadelphia journeys, for it took many years to bring the Harvard school up to the Philadelphia standard. Many young men contented themselves still with completing their professional studies in the offices of some licensed practitioner; a few took a two-term course at the Harvard school, but the more ambitious travelled away to Europe and to Philadelphia to complete their studies and receive the doctor's degree. In those days Philadelphia had this lead over Boston in the advantages it offered medical students, that it provided abundant clinics at the old Pennsylvanian Hospital. At Harvard there was no clinic worth the name. A few patients were shown weekly at the ancient Boston almshouse, but the school proper was in Cambridge, a two hours' journey from Boston then, and the instruction given in Cambridge was altogether didactic. I am not sure but what the total instruction of those times was extremely good instruction. In a measure we have returned in these days to a similitude of the ancient method. Largely the instruction was personal. A group of two or three young men studied under and received the active directions of an experienced physician, and supplemented the knowledge of practice thus acquired, by the didactic lectures of Warren and Waterhouse in Cambridge.

A younger generation as it came along, however, was dissatisfied with the old method. The young men were convinced that a medical school two hours from the metropolis could not flourish; and well-equipped physicians returning from London and Philadelphia urged the importance of re-establishing properly the somewhat somnolent Harvard school. We must remember, however, that the views of a community of 100 years ago differed materially from modern views. The laity feared great bands of medical students, regarding them as vandals; while practicing physicians had a natural feeling of jealousy of a medical school, fearing that it would detract from their own importance as educators, and would raise to an unduly prominent position in the profession the teachers in the school. If the development of Boston medicine had depended upon a majority vote, uninstructed by the enlightened few, there can be no doubt that the Harvard school would have languished obscurely in Cambridge for another generation, or would have disappeared; but fortunately some in the community were coming to take broader views, through the stimulus of such general educational enterprises as I have already mentioned, and through the urging of young enthusiasts fresh from the hospitals of Europe. Of the latter class, John Collins Warren and James Jackson, six years established in practice, were the most active; and Warren's father, John Warren, the honored professor of surgery, lent himself earnestly to the forward movement. Curiously enough his colleague, Benjamin Waterhouse, professor of practice, himself a product of European schools, opposed bitterly, and to the end of his career as a teacher, the plan for medical school expansion. He was a didactic teacher, little given to the arts of clinical instruction, and he seems to have feared the comparison and rivalry of an association with the proposed new professor of clinical medicine, young James Jackson. But liberal views came eventually to prevail through much travail and grievous heart-burning. Waterhouse left nothing undone which might obstruct progress. He joined with others in an endeavor to anticipate the Harvard movement, by establishing in Boston a rival school of medicine to be known as the College of Physicians; and when that endeavor failed he attempted to damage his colleagues by publishing what the corporation of the college designated as false, scandalous, and malicious libels upon the other professors, which had a tendency to injure their characters, offend their feelings, and diminish their usefulness in the university. The outcome of it all was that Waterhouse was forced to resign, after the school had been removed to Boston, which was accomplished in 1810.

Then the faculty was reenforced and reorganized, with such strong and notable representatives as I have already named.

So out of much turmoil, eager initiative and vigorous agitation on the part of a rising generation there was launched that small but effective school of medicine whose leaders, after struggling for academic reform in their youth, founded a great hospital in their prime, and in their old age revolutionized surgery by the discovery and introduction of ether anæsthesia.

You will perceive that it was an active, well trained, onward pressing generation, given much to that spirit of progress which prevailed throughout the land; but instructed also in ancient culture, in old-time kindliness, and with an enthusiasm, born of noble, national tradition and the philosophy of the day, for self-help, neighborly benefit and wide-reaching, catholic philanthropy.

We have heard much in recent years of the leaders who struggled in those days; let us turn the page and make ourselves acquainted with a joyous youth who grew up under such teachers, and put their teaching to the proof, Samuel Gridley Howe.

To the average American of to-day Samuel Howe is known, if at all, as the half-forgotten husband only of that distinguished veteran poetess Julia Ward Howe. Truly the pen is mightier than the sword. But he was himself the author of many good things for which American physicians, at least, should cherish him. It was a brilliant, impetuous, heroic nature; with a romantic career—full of lights and shadows, and strange contrasts. Pedantic folk used to call him "the apostle of freedom."

Howe was born in Boston in 1801, nine years before the Harvard school was removed from Cambridge. That was the year which saw the establishment in practice of Jackson and John C. Warren, and the new vaccination of Jenner introduced to these shores. There was little wealth in Howe's family, and the little there was dwindled sadly during the war of 1812; for his father, Joseph N. Howe, a ship owner and maker of cordage, trusted the federal government for naval supplies, and the government failed him. The unhappy merchant was brought nearly to ruin, and his family grew up in poverty. In spite of this there was money supplied for sending one of the boys to college, and Samuel was selected. He went to Brown, whence he was graduated in 1821, at the age of 20, a mature age for graduation in those days. The young man was an optimist born, enthusiast, and a lover of his kind. In his growing years he had seen develop in Boston those useful and pleasant enterprises of which I have told. In spite of commercial embargo and the English war, the buoyant spirit of the people continued to expand. With the fall of Napoleon and the general political reaction which set in throughout Europe, and in the face of the Holy Alliance with its far-reaching purposes, American patriots felt that the liberties of the race had been intrusted to them by a special providence. The Munroe Doctrine threw out a barrier against despotic aggression on these continents; and the youth of the land were growing up with a vivid enthusiasm for liberty, and with generous good will for the oppressed.

I have dwelt at some length on these qualities of our people in those times, because such were the qualities and sentiments which went far towards directing the impulses of young Howe, and moulding his career.

In the year of his graduating from college the insurrection in Greece against Turkish rule broke out, and thrilled the world. Probably no similar uprising ever awoke wider sympathy or provoked a more unanimous applause. Despotic governments trembled and frowned, but peoples rejoiced. Now, Howe was one of the people. While the senates of the old world were avoiding the ugly question of interference in Greece, and premiers were giving their secret instructions; while popular representatives at Washington were waving the flag and fulminating against tyrants, young Howe was pondering all these things. We know how the united uprising of the Greeks, though feebly directed and cruelly mismanaged, was able in three years to sweep away the contemptible opposition of intrenched Turkish misrule, and how the Porte was forced to turn to Egypt for aid against his revolted subjects. During those three years Howe was content to remain a spectator of the struggle, busied meantime with perfecting his education.

After his graduation from Brown he returned to Boston and entered as a medical student the office of Jacob Bigelow. At the same time he attended the lectures in the Harvard school, and the clinics at the Massachusetts General Hospital, finding as instructors Jackson, J. C. Warren, Parkman, and Ingalls. He must have been an interesting student—dear to the soul of such a splendid independent as Bigelow—acceptable even to the hard-headed, brilliant Warren, and his wise, great-hearted colleague Jackson. Such men could appreciate a promising student, and were foretelling an unusual future for Howe, when suddenly he astounded them and the Boston community by announcing that he was going to Greece. Even the restrained writers of the day flutter with protest and amazement when they tell of it. No one encouraged the rashness. The young man was called Byron-mad. No one encouraged him except one eminent man—Gilbert Stuart, the artist, now growing old, who faltered that his heart also was in the venture if only the times were still young for him. He helped Howe to go. He gave him money, got for him a letter from Edward Everett to an old friend in Greece, and with a quavering blessing sent him on his way.

So far it was all very fine, but our adventurer soon found his work cut out for him. When he left Boston, Greece was flushed with success, and preparing confidently for the final struggle. When he reached Napoli de Monembasia and had pushed on to the Greek headquarters, he found himself in a mob of terrified officials, without concert, screaming diverse counsels, savage, fatuous, ungoverned. Three years of horror had demoralised the Greeks, the best of whose leaders had been lost; though the people themselves had become hardy and trained to a cruel guerrilla warfare. In the autumn of 1824, when Howe joined these people, they were waiting for

the coming against them of a great Egyptian armament commanded by Ibrahim Pasha, one of the most vicious and clever reprobates in history; admiral of a considerable fleet, and captain of as blood-thirsty a set of cut-throats as ever twisted a neck. Four years later Howe published a short account of the proceedings of these gentry. Here are his own modest words:

"In the winter the much-dreaded expedition of Ibrahim Pasha, with the Egyptian army, landed at Molai. Attempts were made by the Greek government to get up an army to oppose them, and Mavrocordato accepted my offer to go with them as surgeon. The president and Mavrocordato came to the south of Peloponnesus with such forces as they could raise. At first there was an attempt to organize the army, and I attempted to create hospitals and to organize ambulances for the wounded. But after the capture of Navarino by the Turks, everything was thrown into confusion. Mavrocordato fled to Napoli. The dark day of Greece had come. All regular opposition of the Greeks was overcome. The Turks advanced fiercely and rapidly up the Peloponnesus. I joined one of the small guerrilla bands that hung about the enemy, doing all the harm they could. I could be of little or no use as surgeon, and was expected to divide my attention between killing Turks, helping Greeks, and taking care of myself. I was naturally very hardy, active and tough, and soon became equal to any of the mountain soldiery in capacity for endurance of fatigue, hunger, and watchfulness. I could carry my gun and heavy belt with yatagan and pistols all day long, clambering among the mountain passes, could eat sorrel and snails, or go without anything, and at night lie down on the ground with only my shaggy capot, and sleep like a dog."

Long afterward our gentle poet Whittier took Howe for his subject in "The Hero," and described an event which the hero himself recounts.

"I was by chance at Calamata after escaping from Navarino, when a sudden invasion of the Turks forced everyone to fly who could fly. I never shall forget the dreadful scene of confusion and distress, or my feelings, as I galloped through the town, accompanied by Ernest, a gallant young Swiss, for we passed many poor beings, old or sick, who were unable to fly on foot, and who stretched out their hands praying for God's sake that we would save them; but selfishness and the pressing danger made us turn a deaf ear, and think only of saving our own lives. We had left the town and were hurrying across the plain, which was occupied with fugitives, when I beheld a wounded soldier sitting at the foot of an olive tree, pale, exhausted, and almost fainting, but still grasping his long gun as if he meant to have a last shot at the expected foe; it was Francesco, who had been dreadfully wounded a few days before, and had staggered thus far from the temporary hospital at Calamata, on hearing the alarm. The poor fellow cast a supplicating look at us as we passed, but said not a word. That look cut me to the soul; had he presented his gun and demanded my horse, it would not have so moved me; I could not but turn my head after we passed him, and seeing him still looking after us, as I thought reproachfully, I pulled up my horse, and on calculating the distance, found I had time to gain the mountain; of course I turned back, mounted the poor fellow on my beast, and thus easily reaped the rich reward of his gratitude."

Time fails us; the narrative runs on for many pages. We know how the Egyptians over-ran the land, and how at last the fleets of England, Russia, and France were sent to intervene. By that time Howe had been three years in the Greek service, and was acting as surgeon-in-chief of the Greek fleet, a formidable collection of three frigates, two sloops and half a dozen wherries. On October 20, 1827, the strong armada of the European allies bottled up the Turco-Egyptian fleet in the harbor of Navarino, and annihilated it in an action as blood-curdling as the heart of Ibrahim himself could have asked. We are not told what part the Greek fleet, with their surgeon from Suffolk county, took in this action, but it is probable they were content to be spectators.

The slaughter of the Egyptians ended Turkish rule in Greece. Peace was established after much tribulation, and in the course of time a limited monarchy was set up with a Bavarian prince on the throne, as the figure-head of the western powers. Immediately after the battle of Navarino, however, Howe saw that the country was falling into a state of poverty and starvation. He was a humanitarian first, a physician and a soldier afterwards, so he resigned his office of surgeon-general, and posted back to Boston to proclaim the good tidings, and raise money for his suffering Greeks. The estimable ladies of Massachusetts listened over their teacups to the strange tales of the young Ulysses: they were moved to hold a fancy fair in Faneuil Hall; their husbands drew out their pocket-books, and Howe was despatched back to Greece with a ship-full of food and clothes. Then there was more trouble. The unhappy descendants of Plato and Pausanias had fallen to fighting among themselves, and sundry brigands with high-sounding titles attempted to relieve the missionary of his stores. Fortunately our old frigate Constitution happened to come along, and a file of marines from the vessel settled the dispute among the discordant Greek patriots. Howe distributed his good things, said good-bye to his mendicant comrades, and returned peacefully to his own country. The pathos and the humor of it all sift down to us through the century, and one fancies the picture: the ragged jabber of the poor, patched, huddled wretches, crouching among the ruins of departed Greece; each with a loaf of Yankee bread in one hand, a rusty dirk at the waist, smearing his face with farewell tears, and shouting to our departing hero as he steps smartly upon the deck of the neat cruiser, waves his hat and sails away for the smiling land across the polished sea.

In 1828, with Howe's return from Greece, the adventurous chapter of his life seemed to close; but other chapters and other adventures awaited him. He was an eager, enquiring soul; looking ever for something new, always appearing to tilt at wind-mills; but out of each bout bringing a measure of practical success, and hastening to new encounters. He was not content to tread in beaten paths, or gather laurels in familiar fields. While his contemporaries were earning snug

incomes in the old lines of practice, Howe was laying his own new lines, and attacking problems of disease hitherto held incurable. His works do live.

First he turned to the education of those born blind. A hundred years ago there was no future before these unhappy folk, save poverty, ignorance, and dependence, or suicide—and suicide even is not readily to be attained by one who cannot see. Howe was fortunate enough to secure the sympathy and support of Dr. John D. Fisher, a young man, one year his own junior—himself a philanthropist and with a private fortune. With Fisher's aid Howe took up the problem of teaching the blind and began his studies by visiting Europe again to investigate the Valentine Haüy methods then employed in Germany and France. In Europe he fell upon more adventures. France was in the throes of her second Revolution, and Howe reached Paris in time to see Louis Philippe seated insecurely upon the throne. Then Lafayette found him out and persuaded him to go on a mission to persecuted Poland in her death struggle with Russia; and to carry to the Poles supplies sent to them from their friends in America. So he became a filibuster in a small way. But the experience was a short one. The Poles were at the end of their tether. Howe visited them, accomplished his hazardous mission, and turned back to Berlin for the study of the blind. But the affair was not so simple, and he learned that free American citizens are not free to dabble casually in international politics. On the day of his arrival at the Prussian capital he was arrested by order of the government because of his Polish doings, was imprisoned and was left to ruminate for five weeks in a cell. But solitary confinement could not tame Samuel Howe. He secured some new German books on the education of the blind, and set about translating them. Years afterward the king of Prussia sent him a gold medal for his success in teaching Laura Bridgman, and the humorous philosopher tells how he calculated that the value of the medal offset exactly the charges for his fare while a guest in the German prison.

In 1832, when 31 years old, Howe settled down in Boston to that part of his life work for which he is most famous—the education of the blind. Happily Fisher stood by him; so did John Homans and Edward Brooks—names well known to-day in Massachusetts. Howe was full of ideas new to this country, and his active intelligence so supplemented the thoughts of others that he soon found himself a lonely pioneer in the work. Here is an interesting letter from a friend of Horace Mann to one of Howe's admirers.

"When we first became acquainted with Mr. Mann he took Mary (afterwards Mrs. Mann) and me to a small wooden house in Hollis street where, in the simplest surroundings, we found Dr. Howe with the first half-dozen pupils he had first picked up in the highways and byways. He had then been about six months at work, and had invented and laboriously executed some books with raised letters, to teach them to read, some geographical maps, and the geometrical diagrams necessary for instruction in mathematics. He had gummed twine, I think, upon cardboard, an enormous labor, to form the letters of the alphabet.

"I shall not, in all time, forget the impression made upon me by seeing the hero of the Greek Revolution, who had narrowly missed being that of the Polish Revolution also; to see this hero, I say, wholly absorbed, and applying all the energies of his genius to this apparently humble work, and doing it as Christ did, without money and without price. His own resources at this time could not have paid the expenses of his undertaking, with all the economy and self-denial he practiced. The fuller purse of his friend and brother, Dr. Fisher, assisted him. Soon after our visit to him, he brought out his class for exhibition, in order to interest people and get money sufficient to carry on the work on a larger scale. The many exhibitions given created a furor of enthusiasm, and Col. Perkins' great heart responded to the moving appeal. He now offered his fine estate in Pearl street, a large house and grounds, for the use and benefit of the blind, provided that the city of Boston would raise $50,000 for the same purpose."

Howe was no dreamer. He was a man of affairs; a sane humanitarian; a tempered enthusiast. New working machinery was necessary; he created it, instructing his assistants so thoroughly that later, when the Sydenham school was established in England, a corps of Howe's former pupils were secured as teachers. He invented a novel form of raised letters for the books of the blind; and the first product of his press was a Bible which was published in 1843—a book half the size, and produced at half the cost, of that Scriptures for the Blind then recently brought out in England.

As a school-master of the blind, Howe was prolific of new and shrewd ideas for the discipline of children. The old Adam enters into these youngsters as well as into their more fortunate fellows whose vision is unclouded. Howe used to maintain that punishments and rewards are mere conventions. Stand a boy on a stool, with a paper-cap on his head; tell him that he is good and happy there and to be envied, and watch him preen himself like a young peacock. Give him a box of caramels, marked medicine, and see him groan and weep as he chokes them down. So Howe inspired his pupils with a sense of receiving merit-marks when they went to bed early, took cold baths, ate a wholesome diet, and exercised daily in the open air.

With this work for the blind securely launched, Howe found himself a mature man of many cares and experiences, approaching middle age. He was untiring. To test upon himself the continued sense of total darkness he blindfolded himself, and so went about for weeks. He learned to use the blind boys' types as skillfully as his best pupil; and with his eyes darkened he might be seen wandering about the streets in tow of a dog on a string. By such means he came to have an intimate appreciation of the atmosphere, the sensations, and the limitations of the blind, their capacities and their possible ambitions. Truly it was a care of the blind leading the blind; but ditches were friendly in those days, and walking was on the level.

Those were indeed times when light was beginning to shine in dark places. The great wave of modern altruism was rising. New ideas of expanding helpfulness were awaking civ-

ilized minds. In France and Germany even honest men were seeing visions, while in Great Britain and America such popular prophets as Charles Dickens were lashing abuses, breaking down intrenched officialdom and rending consecrated cruelty. It was that era of political liberalism which culminated in the English Reform Bill, the Continental Revolution of '48, the freeing of Italy, the Emancipation of Russian Serfs, and the American Civil War; while behind these great movements there advanced haltingly, at times timidly, often mistakenly, as Brook Farm could testify—but always surely, that deeper, more wide-reaching wave of social liberalism, which was beginning to teach men that a drunkard is not a noble fellow; that a bully is not a hero; that poverty is not a crime; that weakness is not contemptible; that labor is not disgraceful; that misfortune is not misconduct; that the maimed, the halt, and the blind should not expiate the sins of their fathers; that the love of nature, of little children and of dumb creatures is not ignoble, and that the uplift of man is an undertaking worthy the best culture, the perfect science and the life-long effort of the finest minds. Such conceptions of a better humanity were in the making when Samuel Howe was in his prime.

Himself a leader of the silent revolution, he moved on from task to task; his clear intellect discovering new points of attack, his genius lighting the pathway to achievement.

In the last analysis the object of all human endeavor is human happiness. Howe was one of those rare men to whom this truth is a present fact. He saw that happiness for the individual is in direct relation to the temperament, the experience and the purposes of the individual. He aimed at relieving misery on a great scale, at raising to a higher level whole groups of men; but sanely, he saw that cakes and ale suffice for most of us. Caviar and champagne are not necessary for humble souls. Nonsense-hubbub did not spur him to the impossible; nor the groans of cynics turn him aside from the work in hand. He was a prophet of fairplay.

One conceives with difficulty the intellectual limitations of a person deprived of nearly all senses except the sense of touch. The state of a blind man is sad enough, but Howe's most famous pupil had neither sight, hearing, taste, nor smell. The training of such an unfortunate to a perception of the good things of life—to an appreciation of literature, music, and art is incredible at first thought, but Howe succeeded in this astonishing task. His subject was Laura Bridgman, the famous blind deaf-mute, whom he found at Hanover, New Hampshire, brought to Boston, when she was a child of eight, and educated at the Perkins Institute. Dickens describes the girl. That great man had a constant curiosity about and interest in schools, asylums, and prisons, making them the first object of his visits to new places. His delighted appreciation of the story of Laura Bridgman appears in a charming sketch.

For 43 years Howe was superintendent of the Perkins Institute. That work is his monument; but like other busy men he found time for other things. He became interested in the state of deaf-mutes, and in season and out, he preached his convictions. Especially the feeble-minded among such children claimed his regard. He asked permission of the Asylum at Hartford to test his convictions there, but was refused. Then he undertook experiments of his own. With two feeble-minded deaf-mute children as pupils in their own homes, he began quietly a system of simple instruction; teaching them easy and familiar arts by constant repetition and practice, until the doing of their tasks became to them automatic. Quickly parents were interested and then enthusiastic. The interest of the children themselves was stimulated, and their feeble intelligence aroused. The investigation was soon placed beyond the experimental stage. Howe demonstrated that the children need not grow up helpless dependents, but in some fashion might become humble bread-winners; then he presented his scheme to the authorities of the Commonwealth. The authorities approved; the legislature took action, and the small beginning developed into that useful institution, the Massachusetts School for Feeble-Minded Children.

One regrets that Howe had passed his prime when the Civil War came. I believe that at his best he would have been a great figure in that struggle. The double interests, emancipation, and union, were certain to appeal strongly to a man of his training and sympathies. He became actively engaged in the anti-slavery movement as early as 1851, and for several years was an editor of the "Commonwealth," a journal of that cause. During the war he was employed as a member of the Sanitary Commission, and was busily concerned in establishing the Freedman's Bureau. It was all good, serviceable inconspicuous work. He had then reached the age when an active man, with his reputation made, is in demand for everything from an after-dinner speech to the presidency of an insurance company, and Howe was unable to escape such burdens. In 1865 he was made chairman of the Massachusetts State Board of Charities, in which position he proved an untiring reformer, to the amazement of his breathless associates. His "General Principles of Public Charity" was a textbook, and is a classic still in demand.

In 1869 Howe had an experience which took him back to the scenes of his youthful crusade of forty years before. The Cretan insurrection of '66 was becoming an international problem. Greece was taking sides with Crete against Turkey, and the powers were bestirring themselves in the matter. But Howe was bestirring himself also. While cabinets were settling the status of the unhappy island, and handing it back to the gentle leading of Turks, Howe was organizing a relief expedition to feed and clothe the destitute people. He followed his plan of 1828; raised a large sum of money, loaded a ship with supplies, and visited Crete. His work there was delicate and hazardous, but he completed it, and saved thousands from starvation. Then he visited the Greek mainland, and learned to his delight that he was not forgotten there. The visit was a triumphal progress, for he found himself one of the immortals among those warm-hearted people. At threescore-and-ten the freedom of cities is pleasant, and laurel still becomes the ancient brow.

That was Howe's last happily successful endeavor. He returned with added honors to America, and promptly was

called to further public work. The federal congress was bestirring itself in the early throes of imperialistic ambition, and folk talked seriously of annexing the islands of the sea. Santo Domingo was their first object, and thither went Howe with other forlorn commissioners, by direction of President Grant. It was a situation of curious paradox,—the Apostle of Freedom, the Hero of Greece, and the Champion of Slaves, sailing away on a mission to annex the parti-colored rabble of a farcical Carib republic. The object was a failure, as we know.

Howe came home, but went back later to the island, seeking health and forwarding a commercial enterprise. This expedition was a double failure, and our philosopher returned to Boston a broken man. His end was near. Much buffeting and novel strivings do not conduce to a peaceful old age. He died with little more ado, in his 75th year, on the 9th of January, 1876.

We have seen that here was a man of singular abilities, of noble aims, of quaint simplicity, of perfect courage. Among the great physicians of America his career is one of the most romantic and varied, and his accomplishments lasting. It is a name to be guarded in our annals, for he wrought and suffered much. In his native town they paid him public honors, and great ones of the earth told what he had done.

Here are the final charming words of Howe's old friend, the poet-statesman Hoar: "His is one of the great figures in American history; I do not think of another who combines the character of a great reformer, of a great moral champion, of a great administrator of great enterprises, requiring business sagacity and wisdom as well as courage, always in the van, with the character also of a knight-errant who crossed the sea, like the Red Cross knight of old, to champion the cause of liberty in a distant nation. There was never on the soil of America, fertile as that soil has been of patriots and heroes and lovers, a more patriotic hero, a more loving knight."

AN ADENOMA OF ISLAND OF LANGERHANS.

By HENRY F. HELMHOLZ, M. D.,

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The rarity of benign tumors of the pancreas and the interest as to their histogenesis makes it seem of sufficient value to report this case, which is otherwise of no great interest. The origin of epithelial tumors of the pancreas may be threefold: (1) from the duct epithelium, (2) from the pancreatic cells proper, and (3) from the cells of the Langerhans islands. Tumors arising from the first two of these sources have been repeatedly described, but growths originating in the islands of Langerhans are rarer in literature. In 1902 Fabozzi[1] reported five cases of carcinoma of the pancreas, all of which he describes as arising from the islands of Langerhans. Reitman[2] in an article published in 1905 is very emphatic in his objections to the work of Fabozzi, insisting that he had to do with sclerosis of the pancreas in which the approximation of the islands resembled carcinomatous acini. The figures given by Fabozzi are unsatisfactory in that they show only single acini of the tumors. In 1902 Nichols[3] described an adenoma of the pancreas which he thinks took origin in the cells of an island of Langerhans. His photographs and descriptions tally very closely with the adenoma to be described in this paper.

The tumor which measured only 5 mm. in diameter, was discovered by chance when examining the routine block of tissue removed for microscopical study. It was found in the pancreas of autopsy 2364, of the Johns Hopkins Hospital pathological series. The abbreviated protocol is as follows:

H. B., male, aged 65 years. Ward M. 1904.

Anatomical diagnosis.—Arterio-sclerosis; cardiac hypertrophy and dilatation; bilateral hydro-thorax; atelectasis of right lower lobe; chronic passive congestion of lungs; chronic fibrous pleuritis; chronic passive congestion of liver and spleen; chronic diffuse nephritis.

Body is that of a well-nourished negro, 161 cms. in length. The left pleural cavity contains 1600 cc. of clear yellow fluid, the right about one-half that amount.

Heart weighs 500 gms. The right and left ventricles are slightly dilated and hypertrophied, their walls measure 6 and 16 cm., respectively, in thickness.

Lungs are deeply pigmented and in section are of a salmon pink color. The right lower lobe is of dark red color, atelectatic and of leathery consistency.

Spleen measures 11 x 6.5 x 3.5 cms. and weighs 100 gms. The organ is very firm and its capsule thickened. On section the trabeculæ stand out prominently in the purplish red pulp, and the malpighian corpuscles are just visible.

Liver measures 26 x 19 x 6.5 cms. and weighs 1450 gms. On section is shows the typical nutmeg appearance.

Kidneys.—The left kidney measures 9 x 5 x 2.5 cms. and weighs 100 gms. The capsule strips off quite readily, but carries with it numerous small particles of the cortex. The surface is granular and mottled reddish brown and yellow. On section the cortex measures 5 mm. across. The striations are fairly regular. The right kidney measures 10 x 5 x 2.5 cms. and weighs 120 gms. It resembles the left.

Bladder.—On opening the bladder two small angular stones were found lying on a normal cystic mucous membrane.

Pancreas.—On section appears normal.

Stomach and *Intestine* also appear normal.

[1] Fabozzi: Beiträge zur Path. Anat. u. z. allg. Path., Vol. XXXIV, p. 1, 1902.

[2] Reitman: Zeitschrift f. Heilkunde, Vol. XXVI, p. 1; N. Folge, Vol. VI., 1905.

[3] Nichols: Jr. of Med. Research, Vol. III, p. 385, 1902.

Aorta has on its surface numerous atheromatous plaques and ulcers.

The section were stained with hæmatoxylin and eosin, polychrome methylene blue, Mallory's connective tissue stain and phosphotungstic hæmatoxylin.

Microscopical Notes.

The pancreas shows a slight increase in fibrous tissue that is not uniform in distribution, but is marked in certain of the lobes and practically absent in others. The parenchyma cells appear normal, as do those of the islands of Langerhans. In some of the islands the structure is somewhat disturbed on account of postmortem change.

The tumor nodule measured 5 x 3 x 5 mm. It was not visible on the surface, and only on section could it be seen as a dull gray, finely granular area sharply circumscribed on all sides by a thin capsule. The adjoining pancreatic tissue is somewhat compressed, and in it there are several islands of Langerhans which are flattened out. Toward one side where the tumor forms the periphery of a pancreatic lobule, the capsule is well defined, but toward the lobular parenchyma it is made up of only a few strands of fibrous tissue. Its surface is everywhere smooth, except at one point, which is shown at *A* in Fig. 1, where the tumor seems to have grown beyond its capsule. With the connective tissue stain a few fine connective tissue fibers can, however, be demonstrated encapsulating it at that point. The tumor itself has a stroma of connective tissue carrying blood vessels, which is rather delicate and which forms large meshes. In these spaces there lie solid or hollowed out, anastomosing masses of epithelial cells, which are quite widely separated from the stroma, evidently by retraction. They are sometimes many cells wide, without a break in their continuity. In places blood vessels may be seen running through the cell masses, and lying in little spaces among the cells. In other places there are definite lumina about which epithelial cells are radially arranged, and about which they seem more columnar in form than elsewhere. At one point just within the capsule several duct-like acini lie embedded in a band of fibrous tissue as it passes inward from the capsule. The alveoli are lined by a single layer of cuboidal epithelium. Its protoplasm is clear and stains very lightly with eosin, its nuclei stain a very pale blue and contain no chromatin network. Embedded as they are in connective tissue, and not found in any other part of the tumor they undoubtedly represent duct acini that have become surrounded by the advancing tumor edge. The alveoli contain granular coagulated material, together with cells of various kinds, some of which are nucleated wandering cells, while others are red corpuscles. The vascular supply shows nothing of interest.

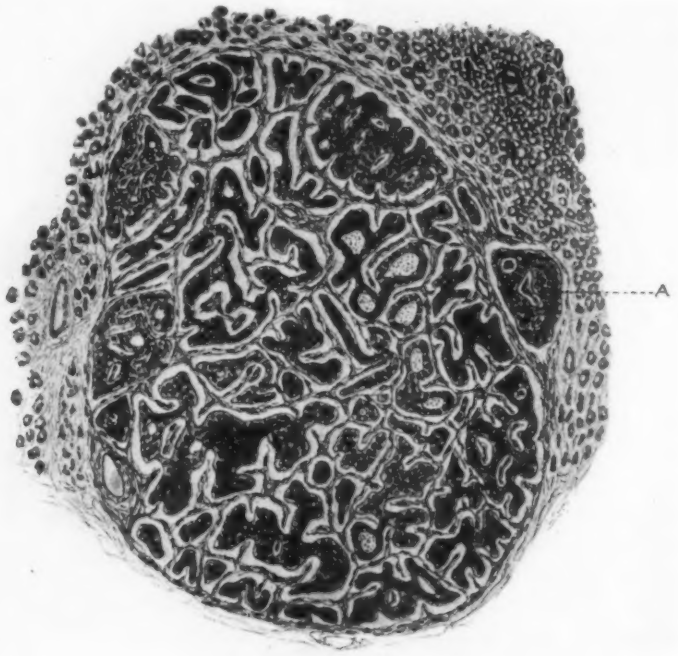

Fig. 1.

Examined under the high power (Zeiss obj. DD. Ocular 4), the cells are in general very indistinctly outlined, rather polyhedral in form, and slightly larger than those of the pancreatic parenchyma. Their protoplasm is coarsely granular, and takes a faint pink stain, in contrast to the basophilic pancreatic cells. About the lumina which have been above described the columnar cells take a redder stain. The nucleus in these cells is situated as far as possible away from the

lumen, the cell margin is quite refractile and sharp, and in places there is an appearance almost as if there was a ciliated margin. The nuclei contain a well defined chromatin network, in which are seen from three to five chromatin bodies. On looking carefully through ten sections of the tumor no mitotic figures were found. The stroma is quite cellular and so finely divided that sometimes a single connective tissue cell is seen lying in the epithelial masses. In the stroma wandering cells are fairly numerous. The pancreatic cells in the capsule are shrunken and atrophic, containing small, irregular, uniformly staining nuclei.

The case reported by Nichols and the one by Reitman are given below. For the other cases the reader is referred to Nichols' article.

Nichols' case.—"Simple adenoma of pancreas." The tumor was found accidentally at autopsy. It consisted of a flattened nodule, of tawny yellow color with a few distended blood vessels over its surface. On section it was definitely circumscribed, rather soft and on pressure exuded a small amount of blood. The tumor was the size of a marrow fat pea. The capsule was regular and at no point infiltrated. Large cell masses bounded by anastomosing bands of connective tissue gave the tumor an alveolar structure. The cells resembled the pancreatic cells, and were columnar or polyhedral depending on the arrangement about the alveoli. The protoplasm was eosinphilic and granular, the nuclei large, round and vesicular. The author regards the island origin of the tumor most probable.

Reitman's case.—"In association with purulent pancreatitis was seen a peculiar adenomatous structure greatly resembling the islands of Langerhans." The tumors were found in a man 62 years of age. The microscopical examination of the pancreas showed a marked inflammation limited to the ducts. Normal islands were present in large numbers. In the head of the pancreas taking up as much as a single lobe were found structures that resembled the islands of Langerhans in their method of construction and in their mode of growth, but in the histological characters of the cells resembled more a tumor arising from the ducts. No relation could be demonstrated to the ducts, however. The cylindrical cells contained no giant nuclei or mitotic figures. The tumor did not show the vascular supply of the islands. The author leans toward the duct origin of the tumor. The drawing the author gives of the tumor shows it to differ considerably from the one described in this article.

In attempting to establish the origin of this adenoma the following facts, briefly summed up, tend to show that in all probability the tumor arose from the cells of the islands of Langerhans:

(1) The anastomosing arrangement of the acini: The structure of individual lobules of the tumor if displaced into normal pancreatic tissue would be indistinguishable from islands of Langerhans.

(2) The intimate relation of the capillaries to the epithelium in some parts of the tumor.

(3) The characteristics of the tumor cell: The polyhedral form of the cell; the acidophile staining of the protoplasm; the varying size of the nucleus; its vesicular character and its numerous large chromatin bodies are characters which the tumor's cells and those of the islands of Langerhans have in common.

NOTES ON NEW BOOKS.

American Text-Book of Surgery for Practitioners and Students. By eleven American authors. Edited by WM. W. KEEN, M. D., LL.D., F. R. C. S. (Hon.), and J. WM. WHITE, M. D., Ph.D. Fourth edition, revised and enlarged. *(Philadelphia, New York, and London: W. B. Saunders & Co.)*

This text-book on surgery is too well known in this country to need any special introduction. That it has proved a useful book to many is indicated by the fact that new editions have been called for at frequent intervals since the publication of the first edition. Any one volume text-book on surgery is certain to be more or less unsatisfactory, in most cases, for the reason that there is so large a field to cover, and text-books written by a large number of different authors are certain to vary in the excellence of their chapters. A chapter that is very satisfactory in this book, is that devoted to the surgical diseases and injuries of the head. Probably no short discussion of this subject can be found which is as entirely satisfactory. The chapter on genito-urinary surgery is also good but it occupies a disproportionally large amount of space. In this particular, the book is far from well balanced throughout. For example, much less space is devoted to the discussion of ether anesthesia than to the technic of the operation of rhinoplasty. Over sixteen pages are devoted to the various methods of treatment alone of stone in the bladder, two pages more than is devoted to the entire subject of appendicitis. We are surprised to see many antiquated, and in some cases, discredited operations given a good deal of space. For example, nearly three pages are devoted to castration and vasectomy for prostatic enlargement; procedures which have been given up as of little value by most modern surgeons and which, the writer admits are still only on trial. The discussion of the very fundamental subject of hand disinfection decidedly lacks the thoroughness which is characteristic of the best American operating rooms. We are sorry to see Fürbringer's method given, in spite of the fact that laboratory and clinical evidence has shown it to be unreliable. From the high death rate which has been shown from the experience of many surgeons, spinal anesthesia does not seem to deserve more than mention, at least not without caution as to its dangers and relatively high mortality as compared with ether and chloroform. The directions for the use of local anesthesia are most imperfect and if followed as given in the book, the anesthesia is certain to be found unsatisfactory. From the title of the book one would expect to see the work of American surgeons receive prominent mention. It is surprising that not only is such mention frequently neglected, but less desirable methods are given in place of American methods. For instance, we are surprised to see that the Connell method of intestinal anastomosis is not given a place among the numerous other methods described and depicted, although

a large number of American surgeons consider it the best method that has yet been devised. Ochsner's method of treating appendicitis is not mentioned, neither are the fundamental studies of Opie in connection with pancreatitis. Finney's pyloroplasty, a favorite method in America, is given two lines, while the procedure of Heineke and Mikulicz, which is now practically never used, is given three illustrations and a page of print. In orthopedic surgery, we miss any mention of the use of the Taylor back brace, the Bradford frame, the Boston Children's Hospital method of applying Plaster of Paris casts for tuberculosis of the spine; Goldthwait's studies on joint affections; and Sampson's thorough work in connection with flat foot. Numerous other instances might be mentioned if space permitted of the lack of recognition of American work in this American text-book. In these days when every medical student is expected to have a special course in gynecology and practically always owns a text-book on this subject, it seems unnecessary to devote valuable space to a very imperfect treatment of the subject, when the space is so much needed for the more thorough discussion of general surgery. The same is true of surgical bacteriology, in which subject, every well-equipped medical school gives a thorough laboratory course. Considerable unnecessary space is also taken up with procedures which are now practically never used and are generally considered out of date. Among these may be mentioned, blood letting, cupping, scarification, and blistering. In too many cases the book is a indiscriminate compilation. Many methods are given with no advice to help the student or practitioner to select the one best adapted to the needs of the special case. Many of these criticisms would apply to several other text-books on surgery which have appeared in recent years. We have already mentioned several admirable features of the work which will commend it to many surgeons and practitioners, and the large number of teachers associated in preparing the book will insure the usual large sale among students.

The Practice of Obstetrics. Edited by REUBEN PETERSON, A. B., M. D. *(Philadelphia and New York: Lea Brothers & Co., 1907.)*

This book is edited by Peterson, but the various chapters are written by several well-known men.

Some chapters are good but as a whole the book is no improvement over the many works on Obstetrics written in recent years; in fact it is not as good as most of them, and therefore we can hardly see the use in publishing it.

Plaster of Paris and How to Use It. By MATIN W. WARE, M. D., Adjunct Attending Surgeon, Mount Sinai Hospital, etc. *(New York: Surgery Publishing Company, 1906.)*

This is an excellent little volume, well arranged and illustrated. Its object is to teach medical students how to make plaster bandages and how to apply them to all the more common needs. From its simplicity and compactness, as well as clearness of exposition its success would seem to be assured, as, so far as the reviewer knows, there is no other book of this size which covers the subject so satisfactorily. R. N.

A Text-Book of Physiology for Medical Students and Physicians. By WILLIAM H. HOWELL, Ph. D., M. D., LL. D., Professor of Physiology in the Johns Hopkins University, Baltimore. Illustrated. *(Philadelphia and London: W. B. Saunders & Co., 1905.)*

The number of text-books of physiology written for medical students and practitioners that each year sees the light of day is no smaller than it is in the case of text-books of other subjects of medical interest. Most of such books are written in a stereotyped fashion, which usually is determined by some successful text-book writer of a decade or two or three ago. Every now and then, however, a work appears which is quite distinctive, it may be, in more ways than one. The book before us fits into this category. A few quotations from the author's preface will serve to indicate some of the qualities which seem to make it distinctive as well as to point out to the reader the author's guiding principles in the preparation of the book. "Simplicity and lucidity in the presentation of facts and theories" seems to have been the author's first aim. That he has succeeded in making a high record may be taken for granted, at least, by those who have already had the opportunity of enjoying other productions of this author's pen.

A second point the author has borne in mind in the preparation of the book is "the need of a judicious limitation of the material selected." "Every specialist is aware of the bewildering number of researches that have been and are being published in physiology and the closely related sciences, and the difficulty of justly estimating the value of the conflicting results." For beginners it is necessary to bring "within reasonable limits" both the amount of material as well as the discussion of details of controversies. "The author must assume the responsibility of sifting the evidence and emphasizing those conclusions that seem to be most justified by experiment and observation. As far as material is concerned, it is evident that the selection of what to give and what to omit is a matter of judgment and experience on the part of the writer, but the present author is convinced that the necessary reduction in material should be made by a process of elimination rather than by condensation." For the purposes of the student "brief, comprehensive statements are oftentimes misleading, or fail at least to make a clear impression. Those subjects that are presented to him must be given with a certain degree of fullness if he is expected to obtain a serviceable conception of the facts." "The obstacle that is most frequently encountered by the student lies in the complexity of the subject—the large number of more or less disconnected facts and theories which must be considered in a discussion of the structure, physics, and chemistry of such an intricate organism as the human body. But once a selection has been made of the facts and principles which it is most desirable that the student should know, there is no intrinsic difficulty to prevent them from being stated so clearly that they may be comprehended by anyone who possesses an elementary knowledge of anatomy, physics, and chemistry. It is doubtless the art of presentation that makes a text-book successful or unsuccessful."

These, then, are the difficulties which the author believed he had to overcome in the production of a successful text-book. The proof as to whether or not the effort was, or, rather, is a successful one, will be the extent to which the work is adopted by classes of physiology. The reviewer's view is expressed in the opinion that the work will come to be the standard text-book in medical schools throughout the English speaking world.

The author's words quoted above will serve to indicate better than the reviewer could state it the style of the book in general.

The arrangement of material also differs from that now in general vogue in that the physiology of the nervous system and that of the special senses follow immediately upon the section, the first, on the physiology of muscle and nerve. Other sections are blood and lymph, the physiology of the organs of circulation of the blood and lymph, the physiology of respiration, the physiology of digestion and secretion, nutrition and heat production and regulation, and the physiology of reproduction. Since the work contains no chapter on the physiology of the cell it is evident that it is the author's opinion that this is a subject which should be eliminated in the process of reduction of material to be presented to the student.

The book abounds in judiciously selected illustrations, many of

which are original. Many references to the literature have been given and "these have been selected usually with the idea of citing those works which themselves contain a more or less extensive discussion and literature." Upon glancing over the footnotes one is struck by the frequency with which the name "Johns Hopkins" appears. The reviewer is unable to decide whether this is to be accounted for by association or by the part this institution has played in the upbuilding of physiology in this country.

Progressive Medicine, Vol. I, March, 1907. A Quarterly Digest of Advances, Discoveries, and Improvements in the Medical and Surgical Sciences. Edited by HOBART AMORY HARE, M. D., Professor of Therapeutics and Materia Medica in the Jefferson Medical College of Philadelphia. Octavo, 280 pages, with illustrations. *(Lea Brothers & Co., Publishers, Philadelphia and New York.)*

The subjects dealt with in this volume are: Surgery of the Head, Neck, and Thorax, by Dr. Charles H. Frazier; Infectious Diseases, including Acute Rheumatism and Croupous Pneumonia, by Dr. Robert B. Preble; the Diseases of Children, by Dr. Floyd M. Crandall; Rhinology and Laryngology, by Dr. D. Braden Kyle; and Otology, by Dr. B. Alexander Randall. The reviews are carefully prepared, and the most important articles that have appeared during the past year under these various titles fully abstracted. The volume is thus useful largely as one of reference, as with its index it furnishes an easy means to find out what has been written on a given topic within twelve months.

R. N.

A Text-Book of Ophthalmic Operations, by H. GRIMSDALE, M. B., F. R. C. S., and C. BREWERTON, F. R. C. S. *(Chicago: W. T. Keener & Co., 1907.)*

The title of this book is Text-Book of Ophthalmic Operations and, if the purpose is to familiarize the reader with the names of various men who have modified accepted operative procedures in more or less minor ways, it will serve its purpose. We assume, however, that it is the intention of the authors to produce a text-book which would describe in sufficient detail and with clearness operative procedures generally adopted at the present day, and if this was their intention, they have surely failed.

The book shows no evidence of originality. The various operative procedures are described oftentimes with the lack of the detail and precision which would insure success, and there is an absence of suggestions as to the choice of operations, and no attention is paid to the consideration of the various problems of operative diagnosis, *i. e.*, cases suitable for operation, time for operation, etc. Operative preliminaries which play such an important role in eye work, *i. e.*, means of rendering the conjunctival sack as free as possible of bacteria, the use of cocain preparatory to cataract extraction, the importance of using atropin before doing a discission are subjects which are not mentioned in its pages, although they are extremely important. For instance, before describing the operation of discission, the authors merely say, "For soft lenses, the method of election is by discission." Here we find no mention made as to what constitutes a soft lens, nor the importance of using atropin eye drops before and after the operation without the use of which the operation might be ruinous.

Many of the descriptions of the operations are so incomplete as to be useless; for instance, the operative treatment of chalazion is dismissed with the statement "Oftentimes it is enough to incise them from the conjunctival surface and evacuate their contents." The reader who wishes to know how to do is no wiser from having read this. Again in the treatment of lachrymal affections no mention is made of the means of passing the probes, the difficulties met with, etc., which a reader of a book of this title has a right to expect. While the operation for cataract is described in some detail, no mention is made of the after-treatment of the case—as to the use of atropin, bandaging one or both eyes and for how long, details which worry the operator more than the operation itself, and upon which the success depends so much.

In conclusion, we must say that while the authors have gone out of their way to describe various operations which are of no value, *i. e.*, Hanock's operation, Querenghi's, Heine's, Hern's, etc., they have not described the important and recognized standard operations with the clearness, fullness, and exactness which one must demand from a book of this character. We consider this book of no value to the advanced worker and of no value to the inexperienced one, who would soon get into disaster if he had no other help than that derived from this work.

The lack of precision, care or "finesse" so evident in the preparation of the text is likewise shown in the illustrations, which, while only schematic, are very crude and "clumsy" and have no tendency to impress one with the delicacy of the operative manipulations on or about the eye.

B. B. B., JR.

The Integrative Action of the Nervous System. By Charles S. SHERRINGTON. *(New York: Charles Scribner's Sons, 1906.)*

Epitome.—The parts of the work which readily admit of being summarized are the following:

The nervous system unites separate organs in such a manner that there results "an animal possessing solidarity, an individual." This is its "integrative action." . . . Since every path and part of the nervous system is connected with every other path and part more or less directly, it follows that a stimulus applied anywhere can affect the whole system to a greater or less extent, and that a truly *simple reflex* cannot exist. Nevertheless the simple reflex is a very convenient abstraction and may be regarded as the ideal unit of nervous action. The characteristics of simple reflex conduction will be considered first, and subsequently the coordination of reflexes will be discussed. . . . . Every reflex action is separable into three processes and every reflex arc into three parts corresponding to the processes in question. These parts may be called the *receptor*, *conductor*, and *effector* organs. The reflexes which form the basis of the discussion are those which have been carefully studied by the author in the spinal mammal, namely, the flexion reflex, the scratch reflex, the extension thrust and the crossed extension reflex. There are also frequent references to the work of others on other groups of animals invertebrate as well as vertebrate. . . . . Reflex conduction differs from nerve trunk conduction in several particulars, *e. g.*, in the former the time elapsing between the stimulation and the response is longer, the after effect is prolonged, the direction of conduction is irreversible and so forth. A study of these peculiarities of reflex conduction leads to the conclusion that there is interpolated into the reflex path a region (*synapse*) between axon and dendron which has different properties from the rest of the nervous arc. The phenomenon of Wallerian degeneration supports this view which may also be expressed by saying that there exists some sort of interneuronic plane of separation. . . . Reciprocal inhibition or the inhibition of muscles antagonistic to those excited is a frequent phenomenon in reflex action. Since inhibition can be obtained by stimulating the lateral cephalad end of the divided cord, it is evident that the inhibitory process does not occur in the receptor or first afferent neuron but must take place somewhere nearer to the motor end of the reflex arc. The very great importance of inhibition as a factor in coordination of reflexes can be realized by comparing the normal animal with one which has been poisoned

by strychnia or tetanus toxin. These substances can be shown to convert the normal inhibitory process into excitation with the result that coordination is completely lost. . . . A given receptor transmits only those stimuli which are applied to the one small area which it supplies, and therefore is in a sense a *private path*. On the other hand, all reflexes which act upon the same motor mechanism travel over paths which must converge upon the effector which thus becomes the *common path* of all these reflexes. The essential feature in the coordination of reflexes is the adjustment which prevents the interference or conflict of reflexes which employ the same common path. . . . Reflexes which employ the same common path in the same way, that is, which either excite or inhibit the end organ, reinforce each other so that a response may occur even when all the stimuli are subliminal. These are *allied reflexes*. Reflexes which employ the same common path in different ways, that is one excites while the other inhibits, are *antagonistic reflexes*. The result is not the algebraic sum of the results obtained when both occur separately. One of the reflexes becomes for the time *prepotent* while the other drops out entirely. . . . While the occurrence of a reflex favors the simultaneous production of allied reflexes, it also favors the subsequent production of antagonistic reflexes. For example, flexion facilitates subsequent extension and this a still more subsequent flexion and so on. The advantage of such an arrangement in such reflexes as walking, scratching, and so forth, is obvious. . . . Reflexes which are *extro-ceptive* in character, *i. e.*, due to external stimuli applied to the skin, may be reinforced by proprio-ceptive reflexes (*i. e.*, due to gravity and mechanical stimuli arising in the muscles, joints, and so forth.) Thus when the stimulation of the skin of the foot causes a flexion reflex, this reflex is reinforced and prolonged by reflexes arising in the muscles and joints during the act of contraction and having the same final common path as the extro-ceptive reflex. . . . If the strength of a stimulus is gradually increased the effect spreads involving a greater and greater number of reflexes in the response until a certain limit is reached. In the case of the flexion reflex a minimal stimulus causes a contraction of part of the hamstring muscles only, but on increasing the strength of the stimulus the response becomes more and more widespread until it involves the four limbs, neck, head, and tail. Certain reflexes, however, as the pinna reflex, cannot be elicited no matter how strong the stimulus to the foot. . . . It is usually stated that the nerve impulse travels over one arc rather than another because the various arcs offer different amounts of resistance. It is possible to speak a little more definitely. In order to produce a response the impulse which reaches a synapse must be more than a subminimal stimulus for the next neuron. The neurons differ in excitability and in any one neuron the different dendrites might differ in their excitability. To this the different resistances of the paths is partly attributable. The total resistance of an arc depends partly upon the number of neurons involved and partly upon the threshold of the least excitable neuron. . . . The final common path is used in only one way at a time. Of two contending reflexes one only is prepotent and takes possession of the final common path. The prepotence of a reflex depends upon four factors. These are (1) facilitation—the presence of allied reflexes causes simultaneous lowering of the threshold for the stimulus calling forth the reflex in question or the presence of antagonistic reflexes causes as an after effect a similar lowering of the threshold; (2) fatigue—if after stimulation of one point until fatigue appears a neighboring point be stimulated, the reflex begins again with its original vigor. As the reflexes from the two points have the greater part of their arcs in common, the region where the fatigue occurs must lie near the sensory end of the arc, possibly at the first synapse; (3) intensity of the stimulation; (4) the species of reflex—the noci-ceptive reflexes are those which tend to protect the animal from harmful stimulation, *e. g.*, flexion of the leg on stimulation of the foot. These reflexes are the most potent while those tonic reflexes which are of use in maintaining posture and so forth are the weakest. . . . From the point of view that reflexes are adaptations it is not unscientific to seek for the purpose or end of the various reflexes. In the flexion reflex one sees a protective withdrawal of the hind leg, the extensor thrust is a galloping movement and so forth. . . . *Spinal shock* is a depression or suppression of the nervous functions which is the immediate result of severe injuries of the nervous system. It is most marked in man and the anthropoids. The reflexes are affected in varying degrees, the noci-ceptive least of all. The condition seems to be due to the cutting off of impulses from the mid-brain and pons which originate in the eye and otic labyrinth. . . . Just as we speak of the local sign of a conscious sensation so we may speak of the local sign of a reflex. For example, the foot engaged in the scratch reflex becomes directed to a different spot if the point of stimulation is changed. . . . With the noci-ceptive reflexes are associated certain subordinate movements, for example, growling, snapping, showing the teeth, and so forth. This makes it probable that in the normal animal the noci-ceptive reflexes are accompanied by those cortical processes which are causally connected with the sensation of pain. It is probable, therefore, that the fibers which function in these reflexes are the pain fibers. The noci-ceptive fibers pass up the cord in the ventral part of the lateral column chiefly of the opposite side. . . . Several psychologists have regarded the emotions as due to the perception of altered conditions of the viscera. This view is disposed of by the fact that when the cord and both vagi have been cut, the animal shows no lack of emotion, but may be pleased or angry as before.[1] . . . The relation of the functional areas of the brain to the cerebral convolutions is very inconstant. In surgical operations it is best to test the cortex by electrical stimulation and not to trust to anatomical landmarks. Beevor and Horsley were correct in their statement that the motor cortex occupies a relatively smaller area in the anthropoids than in the lower monkeys. . . . In the movements which are produced by cortical stimulation the inhibition of antagonistic muscles is observed. . . . Under normal conditions certain movements are never obtained by cortical stimulation, for example, closure of the jaw. These movements can be obtained after poisoning with strychnia and tetanus toxin and it is therefore probable that the cortex normally has an inhibitory action on the muscles in question. . . . In *decerebrate rigidity* the contracted muscles are those which are normally unaffected by stimulation of the cortex. The cutting off of the higher centers allows the normal reflex tone of these muscles to become greatly increased. The reflexes are proprio-ceptive and originate in the muscles, joints, and so forth, but especially in the vestibule. It is possible to divide the whole musculature into two parts, the *tonic* and the *phasic*. While the former is called into action in the proprio-ceptive reflexes and is inhibited by the cortex, the latter is extro-ceptive in character and may be called into action by stimulation of the cortex. The former acts constantly and have for its end the maintenance of posture and equilibrium, the latter act intermittently and

[1] The value of this experiment is questionable. The author's dog barked and so forth, and from this we may justly infer that the animal was angry. But we cannot say that the dog would not have felt more angry could its emotions have been accompanied by movements of the legs and changes in the viscera. Indeed we can know nothing about it until we study subjectively the effect upon our emotions of non-irritative section of all the efferent fibers.

are employed in special movements. . . . The consideration of the nervous system as a whole presents great difficulty. It may perhaps help us to understand the cause of the predominence of the brain. If we examine the nervous systems of various animals beginning with the simplest, it is seen that the first step is the development of a summating and coordinating mechanism, the central nervous system. The central nervous system unites not only the organs present in each metamere but also like organs in different metameres. Certain segments develop special receptors. Those of smell, sight, and hearing (distance receptors) have vastly greater possibilities of exercise and usefulness than the local receptors, touch, and so forth. The proprio-ceptive reflexes increase in importance from their associated action with the distance receptors. The most important proprio-ceptors are those arising in the vestibule and semi-circular canals. Thus it happens that in the brain are found the principal extro-ceptive and proprio-ceptive centers. The cerebrum is the ganglion of the extro-ceptive distance receptors, while the cerebellum is that of the proprio-ceptive. This preponderence of the brain over the rest of the central nervous system is the chief factor in the integration of the individual. . . . By an appropriate apparatus spots of light which flicker more or less may be cast upon either or both retinas at will. Experiment showed that the right and left eye images were still distinct when they reached that region of the brain which is associated with consciousness. . . . The attempt to separate psychology and physiology is to be deplored. Much light may be thrown upon the integrative action of the nervous system by the joint working of these sciences.

Criticism.—In its phraseology this work is terse, often elliptical, its transitions are abrupt, its digressions confusing, its subheadings often ill-chosen and the arrangement of the material generally bad. It is usually possible to find out what the author means but this frequently involves a great expenditure of time and energy. In these respects the book is considerably worse than the majority of English and German scientific writings. Apart from the style the work is of unusual merit. The author seems always to look beyond the simple facts and to complete them with his rich but sane imagination, and although his attitude is markedly philosophical it is none the less wholesome and scientific on that account. PERCY M. DAWSON.

Transactions of the American Gynæcological Society, Vol. XXXI. (Philadelphia: Wm. J. Dornan, Printer, 1906.)

As an exposition of the present status of gynæcology in the United States, and of the views of the leading surgeons in this specialty, these transactions are most important, and, therefore, the volume requires no further recommendation to the profession. R. N.

Essentials of Medical Electricity. By EDWARD REGINALD MORTON, M. D., pp. 175 +, XI, with 11 plates and 70 illustrations. *(London: Henry Kimpton. Chicago: W. T. Keener & Co., 1906.)*

Over half the book is a synopsis of the physics of electricity, definitions of electrical units and terminology, short descriptions of various sources of supply and medical batteries and accessories. The various modifications of the constant current in medical application are touched upon, including the more recent high frequency and sinusoidal currents. The chapter on action of electricity on the body is followed by others on electro-diagnosis, surgery and general therapeutics. The final chapter on special therapeutics is very good and contains many valuable hints. One difficulty that the book offers is that the instruments described differ often from those in common use in this country. One method of application especially in vogue in England—the electric bath in its various modifications, we would do well to use more frequently on this side of the water. The book closes with the usual Erb diagrams of motor points, although Erb is not mentioned, and several diagrams of cutaneous innervation.

The book may be particularly recommended in spite of its too frequent typographical errors, to third and fourth year medical students not intending to specialize in neurology, who wish only a short compendium of electro-therapeutics.

W. B. C.

Surgery: Its Principles and Practice. In five volumes. By 66 eminent surgeons. Edited by W. W. KEEN, M. D., etc. Vol. I, Octavo of 983 pages, with 261 text-illustrations and 17 colored plates. *(Philadelphia and London: W. B. Saunders Company, 1906.)*

This is the second large "practice of surgery" which is appearing at the present time in the United States, and whether it may be the publishers or the profession who demand such works, it is difficult to state; but it seems a pity that these two rival publications should be in the market at the same moment. Bryant and Buck's is to comprise eight volumes, and will, therefore, be somewhat more comprehensive than Keen's, but whether it will be more popular remains to be seen. With men like Mumford, Crile, Bland-Sutton, Adami, the two Da Costas, Frazier, and Martin contributing to the first volume of Keen's "Practice of Surgery," its success should be assured, if the remaining volumes are written by surgeons of equal merit and renown. Although, as has often truly been said, "comparisons are odious," yet it seems fair to express an opinion of preference for Keen's work in certain particulars. The volume is less bulky and more easily handled than that of Bryant and Buck, which is distinctly clumsy. Keen's is equally well printed, and its illustrations appear superior. The reviewer also thinks it an advantage to find a bibliography at the end of each article, as in the work under review, which is missing in Bryant and Buck. It may be considered certain that under Keen's able editorship this practice will hold a high place among systems of surgery, and that it will represent the most advanced knowledge of the day in this branch of medicine. The first volume deserves much praise, and is to be recommended in every respect. R. N.

The Practitioner's Medical Dictionary. By GEORGE M. GOULD, A. M., M. D. *(Philadelphia: P. Blakiston's Son & Co., 1907.)*

Dr. Gould's industry is indefatigable and in addition to numerous other dictionaries, and many volumes of essays, he has found time to prepare another medical dictionary, which in his preface he says "is in every respect and detail new." His competence in this line of work is so well known and so thoroughly appreciated, that it is quite certain that this work will be widely adopted by the profession. The volume is well printed, and light in weight, which is a very great advantage. In regard to some of the illustrations their value seems problematical, but as this is a question on which different opinions may well be held, no stress need be laid on the point in view of the general excellence of the book. It has special advantages over some of the other dictionaries in the addition of "the metric system of weights and measurements of doses"; in the use of the "(B. N. A.) anatomic nomenclature"; and in "the distribution in alphabetic order of eponymic terms." There is no better dictionary of medical terms for the laity. R. N.

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